An Experimental Study of Rhythms

by

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I. INTRODUCTION

The study of rhythms or periodicities in connection with continuous work has been a problem of considerable importance in the field of psychology in recent years. To quote one author (58), "There is a periodicity about everything we do; heart action, breathing, eating, sleeping, and the like, occur rhythmically, under undisturbed conditions. Many individuals do their best intellectual work early in the morning, others prefer working late at night; each has his definite work rhythms. The fatigue curve ordinarily obtained in the ergograph experiments reveals rhythms of muscular contractions of higher and lower amplitudes. The knee jerk elicited at frequent, regular intervals over a prolonged period shows the same phenomenon. Workers in factories who make stereotyped movements for hours at a time show periodic fluctuations in their output."

Being well aware of these rhythms which are in the main physiological, the question naturally arose as to whether we should find rhythms in all motor performances, and also in those performances which while they were motor in nature involved learning. Equally important were the questions; what are the factors which determine these rhythms, and do such rhythms persist over a period of time.

The purpose of the present study was to discover whether simple motor performances showed rhythms. The original performance consisted in tracing blindfolded a simple maze which had no culs de sac, but which did have regular niches along the side of the groove through which the subject ran the stylus. Since this problem involved learning, an even more simple apparatus, a square tracing board having smooth grooves, was also used.

A rhythm may be described as a series of successive responses of approximately uniform pattern, each group of responses containing one or more phases of the larger rhythm. In the present study the repetition of similar patterns in the time curve of the particular performance was taken as evidence of the existence of a rhythm.

II. EVIDENCES OF RHYTHMS IN OTHER FIELDS

Since the historical background for this particular type of experiment is rather limited, it is necessary for us to consider the evidences of rhythms in other fields in order to orient ourselves with respect to the nature of rhythms, the conditions of such rhythms and the value of a study of these rhythms.

Rhythms in the Field of Physiology.

In the field of physiology we find almost innumerable examples of rhythms, whose study is valuable in so far as it helps to predict in advance the occurence of certain physiological processes, and because it makes clearer the meaning of certain of the so-called 'instincts'. Such a study also shows the relation between certain physiological rhythms and such behavior as attention.

Galloway (20) reported a diurnal rhythm in the Traube-Hering wave, and Pillsbury (40) found a corresponding rhythm in the attention wave. Slaughter (48) and Bonser (9) have also reported a direct correspondence between the attention rhythms and the Traube-Hering waves. Griffitts and Gordon (21) repeated the work of Slaughter using additional stimuli and more subjects. The most significant of their results came from a series of control experiments which modified Slaughter's original procedure. They found some correspondence between the circulatory rhythms and attention. There was a tendency for the appearance of the visual image to occur during the trough and upward slope of what appeared to be true Traube-Hering waves, and for the disappearance to occur during the crest and the downward slope. They also found no correlation between the lengths of the Traube-Hering waves and the length of the attention rhythm. The length of the attention rhythm seemed to vary with the change in the stimulus.

Amar (5) found that the rhythm and the amplitude of blood pressure increased with the rate and amount of work. Normal work is accompanied by a more or less regular curve, while when the conditions of the muscles become abnormal it is shown by an irregular curve.

Carlson (14) found that the sensation of hunger was dependent on contractions of the stomach which occurred rhythmically. Cannon and Washburn (13) and Cannon(12) have shown that the hunger sensation is not produced until the end of the active period of stomach contraction is nearly reached, when the waves have become very large, but even then it increases in intensity to some extent with the magnitude of the contraction, and disappears entirely when the contractions cease.

Wada (55) found that in a child ten months old, during continuous uninterrupted sleep lasting eight hours, the activity as recorded by a tambour and a spring placed beneath the crib was definitely periodic, the interval between the periods averaging forty-five minutes.

Wada (55) also tested the stomach contractions and activity periods of adults during sleep. The subjects swallowed a stomach tube just before retiring, and simultaneous records were taken throughout the night of the stomach contractions and bodily movements. Besides diffuse activities such as turning over, smaller movements were recorded whenever possible. Adult activity during sleep, just as infant activity, proved to be periodic but the intervals between the period were much longer, varying between two and three hours. The stomach contractions were also rhythmical, much more so than they are in the waking state. The periods of the two phenomena seemed to coincide; when the stomach is quiescent the gross bodily movement is reduced to a minimum, but during the contraction of the stomach frequent bodily movements occur, the largest coinciding with the main hunger contractions.

Jasper and Perkins (26) found distinct evidences of periodicity in chronaxie measurements. They measured the chronaxie of the biceps over a period of two or more hours and found a major rhythmic period about one hour in duration (Figure A). Under hypnosis the normal rhythm disappeared and the chronaxie value was greatly raised. The value of the chronaxie seemed to depend on the strength of the suggestion given to the subject at the time.

The most valuable work on periodicity, in the light

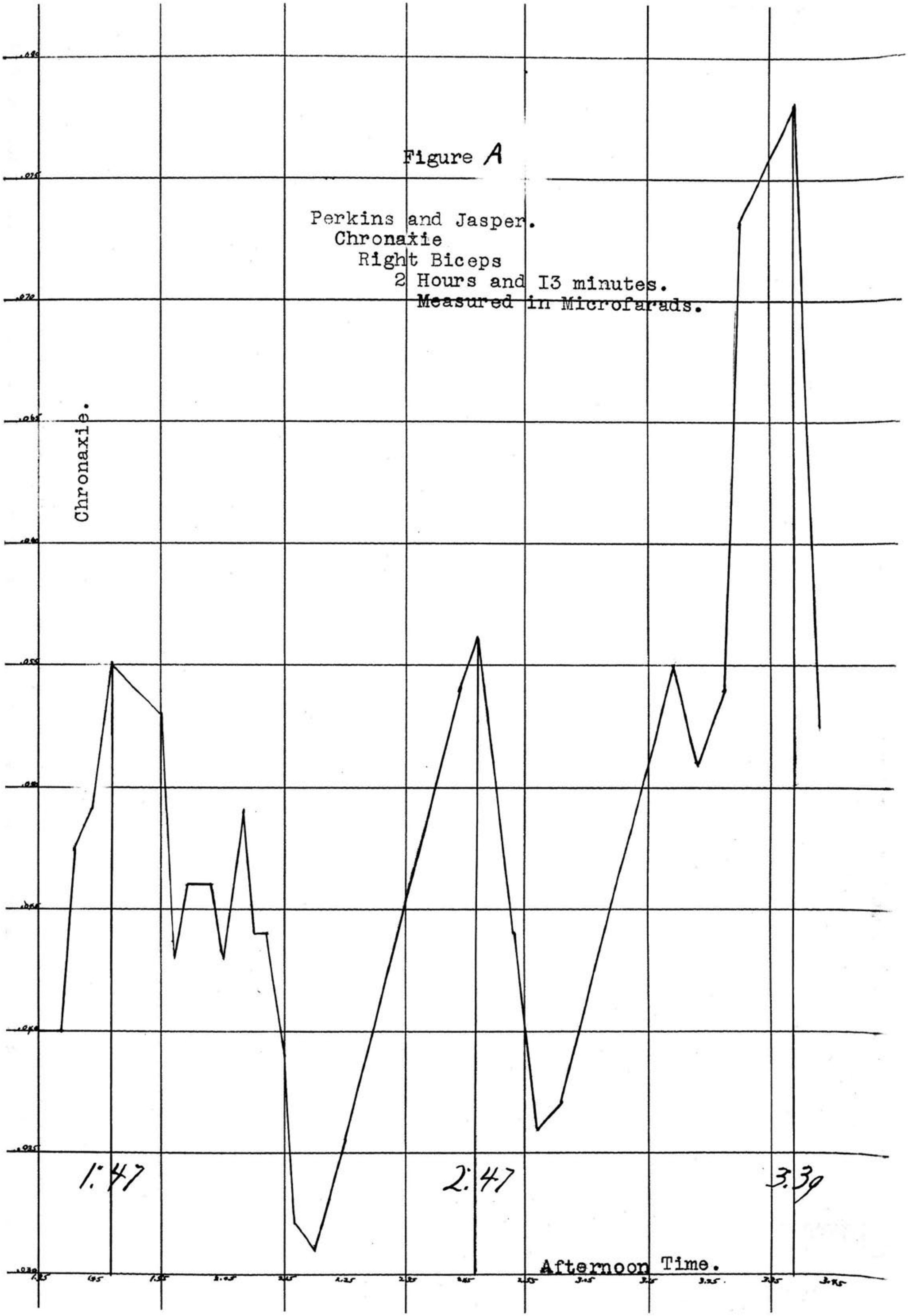


Figure A
Perkins and Jasper.
Chronaxie
Right Biceps
2 Hours and I3 minutes.
Measured in Microfarads.
Chronaxie.
1:47
2:47
3:39
Afternoon Time.

of the present study, is the excellent work of Richter (42) on the relation between certain internal drives and periodicity in the function of certain organs of the animal.

He found that rats exhibited spontaneous activity which was periodic in nature, and which coincided with the two hour hunger rhythms of the animal.

It was noted that the motility of the rats immediately after birth was continuous rather than periodic. For the first ten days it remains constant; then a rhythm begins to appear, and by the sixteenth day clear-cut and very regular rhythmic intervals are present. This result is consistent with the fact that the new born of some animal species show stomach contractions with almost no indication of periodicity, as was indicated by the work of Patterson (36). Some animals such as the guinea pig, rabbit, kitten and chick, unlike the rat show periodicity in both hunger contractions and spontaneous activity at birth. This seems to be related to the fact that the latter animals are more differentiated at birth than the rat.

Richter (42) also found that the rats exhibited larger rhythms of spontaneous activity which extended over periods of four days (Figure B). On the first three days they ran only a fraction of a mile, while on the fourth day the rats ran from eight to ten miles. This periodicity of activity seemed to coincide with the four day rhythm of the ovulation cycle. Pregnancy is followed by a 60 to 95

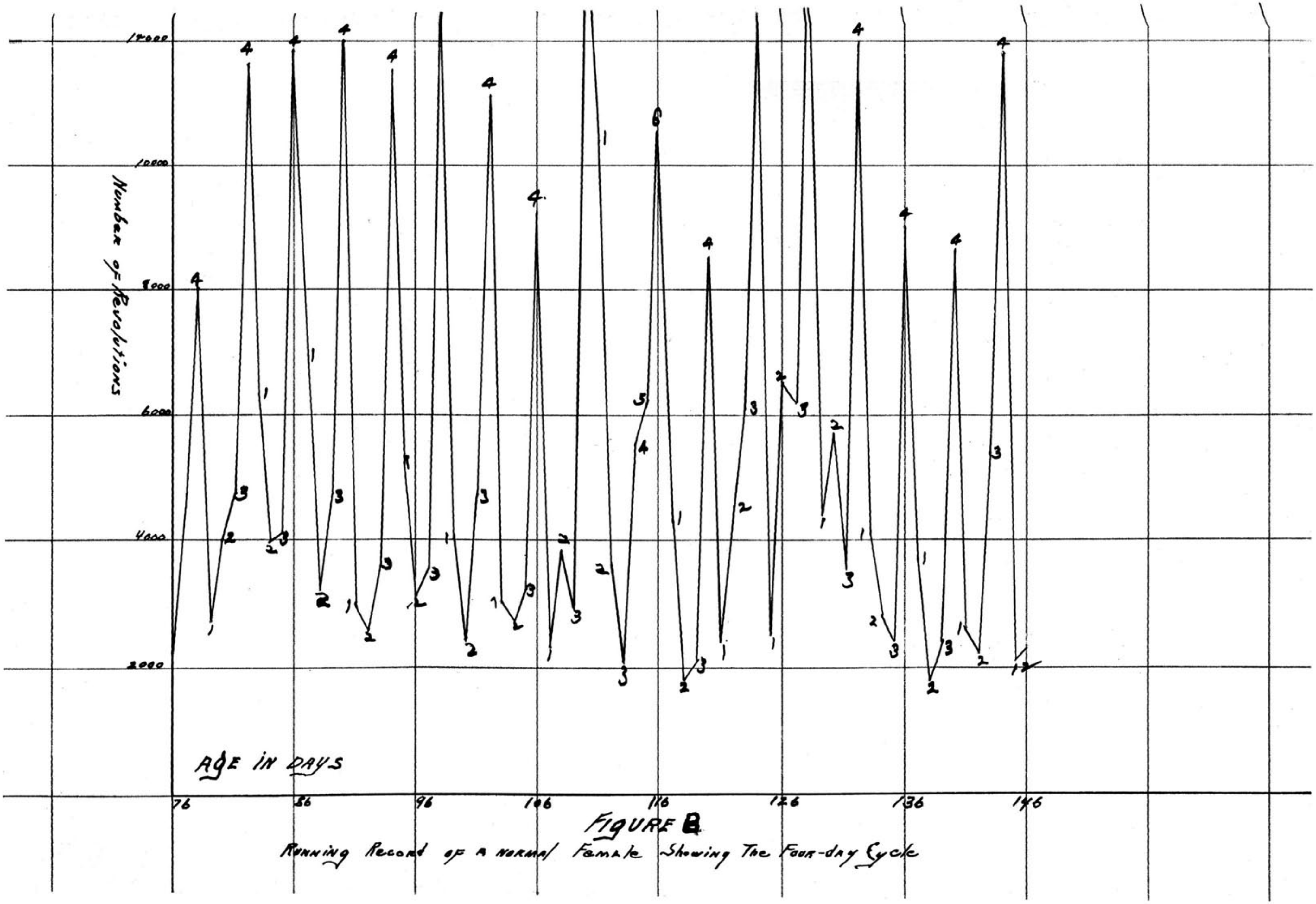


FIGURE B

Running Record of a normal Female Showing The Four-day Cycle per cent decrease in activity as was shown by Slonaker (49). Wang (57) showed that sterile copulation by a vasectomized male brought about the same decrease in activity. Richter (43) showed this activity to be dependent on the ovarian cycle, for spayed animals showed no such rhythmic activity, but when ovaries were implanted the activity began to increase immediately, and grew gradually higher until the normal running level of the female was reached. Then, if the grafted ovary is removed, the activity drops about 60 to 95 per cent.

This same principle has been applied in a search for other cyclic changes in the internal organs, since Richter (42) found periods of activity longer than four days in both males and females after the sex organs had been removed. There are at least two other fairly well defined rhythms, one from seven to ten days, and one from sixteen to thirty days. Slonaker (59) has found a number of other rhythms varying between forty and one hundred twenty days. They have not as yet discovered just which organs are definitely connected with these rhythms.

This work on the simpler forms of spontaneous activity led to the study of the more complicated and specific performances of rats, such as nest-building, and social activities. They sought to answer the question, "what makes rats build nests". The situation was so arranged that nest-building was practically the only outlet for the animal's activity and the other activities were kept constant or eliminated.

Kinder (27) found that if the nests are removed each day rats of all ages will build a fresh nest within the following twenty-four hours. That activity is present and equally strong in both sexes is shown by the records of daily nest-building activities. Moreover nest-building seems to be independent of experience, since young rats thirty days old raised in sawdust build perfect nests out of crepe paper strips the first time these are given to them. Nest-building observed over a long period of time proved to be periodic like the running activity. Here Kinder found that the four day rhythm of the female is present just as it was in the running activity, but it has a very different relation to the cycle. Nest-building is greatest in the dioestrous interval of low running activity and lowest during oestrous when running activity is greatest.

He found that all phases of the nest-building phenomenon have one feature in common that indicates the origin of the activity; every phase can be understood as a part of the heat-regulating mechanism by means of which the body temperature is kept at a constant level. Activity increases in low temperatures and decreases in high temperatures. It is high when there is a tendency for the body temperature to decrease; before puberty, during the inactive dioestrous interval, during pregnancy, and during starvation. It is low at the oestrous period when the animal is very active and the body temperature tends to increase.

In a study made by Davis (16) of 1000 married and 1000 unmarried women college graduates it was found that of the unmarried women 868 admit some form of sex feeling and 272 recognize its periodicity. The latter group was in better health and had more sex problems.

Bartley and Newman (7) have shown distinct rhythms in the action currents of the dog's brain. The volleys of action currents come at regular intervals. The rate of the volleys was shown to be the same as the tremor rate which was found by Travis (54).

Allen and O'Donoghue (4) have outlined a theory of nervous action which holds that the nervous system tends to function in a rhythmical manner. They state: "In connection with sensory receptors, muscles, and glands there are efferent nerves extending to them from the appropriate centres. By means of the reflex actions associated with them, inhibiting and enhancing or facilitating impulses are conducted to the proper end-organs whose sensitivity or responsiveness they control. When any organ has been stimulated into action its normal equilibrium is disturbed, and recovery is accomplished by the two reflex actions acting not simultaneously but alternately, or at least reaching their maxima alternately. The nervous system evidently possesses what may be described as 'neural inertia'. Because of this property, or what is analogous to it, an organ which has been stimulated to activity recovers its normal equilibrium by a series of neural oscillations of a pendular type." This they called the "neural oscillatory effect". "The oscillations may not always appear rhythmical, because every act of measurement is necessarily an additional distrubance. The action resembles the swinging of a pendulum which is given new impulses at intervals."

Allen (1) has shown that the secretion of the paratoid gland exhibits neural oscillation. Allen has also pointed out that the work of Lashley (28) on the flow of saliva showed this oscillatory effect though Lashley himself did not report it. Lashley measured the number of drops of saliva secreted each minute Examination of the graph shows a decided oscillatory effect with quite regular recurrences of enhancement and inhibition. As is to be expected, the curve shows first an enhancement from the normal secretion of one drop per minute to ten, then declines to eight, with subsequent enhancing and inhibiting effects.

Rhythms in the Field of Industry

In the field of industry we find many evidences of rhythms whose study is valuable in that it enables us to increase the output of workers by giving them their rest periods at times when they are about to have a downward slope in the rhythm of their work curve, and also it helps in the distribution of work, and in decreasing industrial accidents.

Hersey (23) set out to study emotional changes in factory workers and found that "emotional tone varies not only from day to day, but also seems to show a longer cyclical trend characteristic of the individual. These periodic emotional cycles in twelve normal individuals studied averaged about five or six weeks in length, the cycle for one man being only three weeks and that for another eight weeks.

It was found that each worker showed definite periodic changes in his average weekly emotional tone which could not be accounted for by environmental happenings, climatic changes, or physiological factors of a kind that were measurable in the plant. Moreover the cyclical movements varied characteristically for each man in regard to length, amplitude, and nature of emotional and objective changes involved. The length of each worker's periodic changes varied, but in no case did the length of any period pertaining to the same person very more than a week from his average. The amplitude also showed similar individual variations. The amplitude of the changes seemed to be more effected than the length by the worker's organic states and relation to his environment.

Wyatt (60) under auspisces of the Industrial Fatigue Research Board made a study of repetition work carried on in a soap factory. His study was made in an attempt to see if there was any relation between working efficiency and amount of intelligence possessed. Although Wyatt did not study the rhythms of the work curve directly he does contribute in the light of the present paper some very interesting results.

The work curves which he gathered were taken on the process of wrapping soap and packing it. Each cycle of movements consisted essentially of wrapping and packing three tablets of soap in a cardboard box and occupied approximately 40 seconds. The process was generally repeated on the average about 720 times a day.

The subjects were asked to give reports as to whether they found the work boring or tedious at any time during the day. Their reports seem to show little correlation between feelings of fatigue or boredom and loss of efficiency as shown by the work curve.

Six operators were observed for four days and the time taken to complete each cycle of movements which included wrapping and packing three cakes of soap in a box was noted continuously. In addition, the nature and duration of all stoppages and interruptions to activity together with any conversations which occurred were also recorded.

The curves show that, in general, the rate of work when unaffected by collecting soap or talking remains fairly uniform throughout the day. When talking occurs, however, the rate of work is considerably increased. The talking seemed to relieve the monotony of the task and allow the workers to relax and thus retarded the onset of fatigue. The most intelligent workers are the most talkative and their work curves also show the greatest amount of variability.

Taking these curves of Wyatt as a whole and interpreting them in the light of the present paper, it is found that the curves show what seem to be quite characteristic rhythms which appear to persist unchanged on the succeeding days. (Curves plotted in time in seconds taken to complete each unit and in the number of units completed.)

Waller and De Decker (56) measured the energy loss in tailors and dock laborers at their regular work. The output of CO_2 was determined every hour throughout the day and in the case of some of the dock laborers the tests were continued for a period of a week. It was found that the curve of production increased during the morning and again during the afternoon, the increase being slightly greater during the afternoon.

A fatigue study made by Link (30) in which three tests were given five times a day for three weeks to 40 girls engaged in the visual inspection of shells gave results which could not be interpreted in any consistent manner. The most obvious result was the persistence of regular variations due to the learning process even at the end of three weeks. Later, the hourly production or output of the same 40 girls was studied every day for a period of three weeks. The resulting composite production curve differs radically from the conventional fatigue curve for work of this nature. Production increased throughout the morning reaching its maximum height shortly before noon. Directly after the luncheon period production, instead of starting with an increase, started with a very marked drop. However, it gradually increased reaching the highest point for the day at about 5:30 P.M. (Circumstances in connection with this study made it possible to obtain figures which showed that a group of 40 shell inspectors performed 3.6 per cent more work per hour while working 10 hours a day than they did while working only 8.6 hours.) This study shows that the curve of production is not influenced wholly by the factor of fatigue, but that it indicates the operation of certain factors within the individual and certain factors in the external stimulus pattern.

Muscio (33) adds to the evidence a study which shows that the value of fatigue tests is doubtful because of the degree of fatigue present when the tests are applied is unobtainable. His results corroborate those obtained by Link (30) in that they afford no evidence that fatigue, as judged by diminished capacity for work, is progressive throughout the day's work. It appears to fluctuate rather regularly throughout the entire day.

Farmer (17) in 1926 gave eight groups of individuals, a total of 1342 subjects, a choice reaction test which consisted of thirty stimuli. The results of the average response times for each group were plotted graphically. These graphs show a remarkable similarity to each other. The most interesting point about these curves from the viewpoint of this paper is the fact that the responses tend to follow a very definite rhythm of long and short reaction times. The intercorrelations of the choice reaction times to each of the thirty stimuli are very significant, since the correlations vary from .737 to .970 all of which are very high. He found also that the performance curves of all groups are very similar in form. The conclusion of this work is very important in the field of industry in that it shows that any improvement made in an industrial task with a view to making it less difficult will tend to effect all the workers the same way though not to the same extent.

<u>Rhythms in the Field of Psychology</u>

In the field of psychology the most important work closely related to the present study is the very excellent work of Bills (8) on "Blocking and Mental Fatigue". The term 'block' refers to those periods experienced by mental workers, when they seem unable to respond to the stimuli until a short time has elapsed. Bills set out to find what governs the appearance of these blocks, what factors determine their frequency, the relation to the principle of refractory phase, and the relation of blocking to the occurrence of errors, and to the amount of previous practice in the task. Several factors make an understanding of blocking important. (1) A more or less rhythmic fluctuation in the degree and direction of attention would cause us to suppose that we should find some corresponding form of fluctuation in the performance level. (2) The work of Forbes (19) and others pointing to the existence of a cumulative refractory period of greater length than the simple phase, suggests that a corresponding recurrent gap should occur in the mental activity. (3) If such recurrent periods of lowered mental functioning occurs we would expect it to have an important bearing on the occurrence of errors.

A block was defined in this study as "a pause in the responses equivalent to the time of two or more average responses". The tests were addition and subtraction, color-naming, reversible perspective, and substitution. Some subjects worked continuously for an hour on substitution and color-naming.

Bills reaches the following conclusions in this study: "In mental work involving considerable homogeneity and continuity, there occur, with almost rhythmic regularity, blocks or pauses during which no response is made; practice tends to reduce the frequency and size of the blocks; the responses between the blocks tend to bunch toward the center, so that a regular wave-like effect as of alternating rarefaction and condensation, is produced; the wave is scalloped in formation, rather than sinusoidal. Fatigue tends to exaggerate the bunching; there is a consistent tendency for errors to occur in conjunction with the blocks, suggesting that the cause of errors lies in the recurrent low condition of neural functioning which the blocks reveal."

The neural mechanism involved in this rhythmical performance appears to be related to the phenomenon of refractory phase. Since the refractory phase does not follow every response but rather occurs after every group of twenty or so responses, it seems necessary to associate it with cumulative rather than simple refraction.

Spearman(52) advances the hypothesis of oscillation to explain variations in the response pattern of the individual, that is, he postulates more or less rhythmic fluctuations in the available mental energy supply of the individual.

Perkins (37) in a study of configurational learning in the goldfish showed that learning curves seemed to ascend in volleys, or to follow a certain pattern which was characteristic for the animal. The patterns were generally preceded by a low point in the curve or a plateau, which Snoddy (51) has called an irradiation pattern. The patterns or volleys in the learning curves show us how maturation proceeds from a low point or plateau, through repeated increments of development. The learning process seems to be going on in certain multiples of a maturation pattern or rhythm that is characteristic for the animal.

Scripture (46) has called attention to the relation between natural rhythms and periods of work. When the two coincide we get the 'most action with the least fatigue'. This factor is demonstrated in the 'route step' of troops on long marches, when each man chooses his own pace. This is very similar to a point made later in this study that in order to get the maximum efficiency in track performances it is best to let the athlete choose the pace pattern or rhythm which is most suited to him.

When Seashore (47) instructed subjects to tap in patterns he found that the length of the group "seemed as a rule" to fall within the range of respiration and pulse periods of all the subjects tested, or multiples or divisors of these periods.

Isaacs (24) who reviewed a large number of articles on rhythm defined rhythm as the experience arising from the periodic, pendular, reflex response of characteristic organs to objective stimulation. He states, "Rhythm arises from the reflex response, and the groupings of the rhythmic pattern are the result of attention."

Philippe (39) in a study of the sense of rhythm points out that there are such things as semi-voluntary and even involuntary rhythms, for example, breathing, the heart beat, and some of the rhythmical movements of the skeletal muscles. A voluntary rhythm may be effected to a large extent by an involuntary or semi-voluntary one. Any of these rhythms is contagious in all of the nerves and accordingly involves all parts of the organism. This very early study seems to anticipate in a small degree some of the later work in regard to the relation between the neural rhythms shown in mental activity.

Miner (32) in a study of motor, visual, and applied rhythms has pointed to several important factors. He found that while his subjects were experiencing an auditory rhythm they also showed involuntary rhythms of head and hand movements. These rhythmic movements persisted even under hypnosis. If the subject attempted to restrain these movements in one muscle they were likely to occur in another muscle, for example in the contractions of the diaphragm and chest, or even in slight or nascent muscular contractions of the tongue or larynx. Some subjects even showed rhythmical contractions of the eyelids. In none of these cases were the subjects aware of these rhythmical movements. (This point is quite important for it shows that in every case the organism is reacting as a whole to the total situation and also seems to show that the rhythm in any mental task is at least accompanied by certain physiological factors, if not the direct result of them.)

Organic rhythms however fail to explain entirely these other rhythms because their period would have to be practically constant. The fallacy lies in supposing that any regular organic pulse of movement could be so changed that its period would agree with whatever length of group was taken. We can experience a rhythmic grouping whether the stimuli be one second or four seconds apart. This range is far beyond that of any organic rhythm.

Miner bases his explanation on muscle waves, which he finds correlate more closely with the rhythmical patterns of the performances than do organic rhythms. Muscle waves vary in the length of their period with the rhythm perceived. They vary at different times in form of grouping for the same rate of stimuli. (It has been held that when a stimulus is applied directly to the cortex, no matter at what rate, the brain sends out rhythmic impulses at a constant rate.) Miner does think, however, that the bodily rhythms help to explain the tendency to favor groups of certain lengths. He thinks that greater pleasure arises from rhythms which most nearly coincide with our normal organic periods.

He found that when he presented a series of lights his subjects exhibited involuntary rhythms as shown by their introspections. Besides these rhythms in the grouping of the stimuli the subjects also had involuntary muscular rhythms. When the subjects were told to produce light flashes at intervals to suit themselves, they in every case produced a rhythm.

Another point of importance in view of the present study is the effect of the introduction of independent rhythmical stimuli on the work curve. Miner (32) found that in mental processes the slow persons seemed to profit from such stimuli, while the quick person was much disturbed. Fere (18), who made a study of the effect of certain rhythmical stimuli on the curve of work as shown in the ergograph experiments, found that certain slow rhythms increased production, while rapid fatigue followed an increase in work when using certain other rhythms.

Allen (2) has shown that the responses of the organs of vision, hearing, taste, touch, temperature and pain, when stimulated follow a similar type of law, which states that some measure of the response is proportional to the logarithm of the intensity of stimulation. It has also been shown that the secretion of saliva, the learning process, the production of heat and the action currents in the nerves likewise conform to the same law. In all cases the graphs obtained consist of two or more intersecting straight lines which show that at intensities corresponding to the points of intersection the response of the stimulated organ alters abruptly in magnitude. These changes in magnitude are due to an alteration of the balance between the reflex actions of inhibition and facilitation.

The most interesting point made by Allen (2 & 3) in the light of the present paper is that the learning process shows these neural oscillations. All learning curves seem to be of the same type, containing a gradual rise marked by oscillations with occasionally a level portion, called a plateau, which represents a prolonged period during which no progress occurs. Allen took the learning curves of Book (10) which represented the acquisition of skill in using the typewriter and interpreted them in terms of his theory of neural oscillation. Inspection revealed the curves to be concave towards the horizontal axis, which suggested a logarithmic form. Smoothed curves were drawn to represent as closely as possible the mean positions as indicated by the broken line of Book's original curve. (These ordinates were plotted against logarithms of the days, and a group of linear graphs was obtained.) In all cases the graphs were represented by the equation

$$N = k \log D + C,$$

where N indicated the number of strokes which represented the degree of skill acquired, or the response of the cortical region concerned in learning, D the number of days practice or the intensity of stimulation, and k and C are constants. The learning curves in this form were exactly the same as those obtained in sense fields.

The linear graphs of learning showed plateaus similar to those for the graphs of the muscles, senses and glands. The same explanation would therefore hold for all, since it had been shown that in the efferent portion of the nervous system there were both enhancing and inhibitory impulses. These were found to act alternately in an oscillatory manner. When an inhibitory action predominates, stimulation may produce stationary or even diminished results. When the enhancing phase appears, further stimulation again becomes effective in producing a more vigorous response than before. From this point of view the 'breathing places' are due to inhibitory phases of more rapid neural oscillations of short duration and the plateaus to those of long period oscillation.

A point of interest in connection with the work of Allen on learning curves is that the writer without knowledge of the work of Allen investigated some of the classical learning curves, notably those of Book (10) for typewriting and those of Cattell (15) for typewriting and also curves for walking and running, using the technique of the present study, and discovered evidence of rhythms in the learning process.

Roff (45) studied the learning process of subjects in making a particular golf shot over a period of several weeks. His curves of percentage of correct shots show evidences of rhythmic performance though he does not point this out. Pankratz (35) repeated the experiment the next year using some of the same subjects. His curves for the percentage of correct shots made show evidences of rhythmic performance and also strikin resemblance to the first part of the learning curve of Roff. Pankratz has also plotted a curve for gross errors taking only those shots which were more than eight inches from the edge of the hole. Since this curve also shows rhythmic tendencies, we may state that in this experiment both the correct and the gross errors came in groups or volleys which occurred rather regularly.

III. PRELIMINARY EXPERIMENTS

The present work began with an attempt to discover experimentally the effects of such factors as athletic training, typewriting, piano playing, competition and suggestion on motor performance. The subjects were twenty-four undergraduate students and four of the University athletic coaches. All were questioned as to athletic training, typewriting ability, and training in other lines such as playing the piano and so forth.

The apparatus for measuring consisted of two telegraph keys mounted opposite each other and connected with electric counters which recorded the number of times the keys were tapped.

The subjects were instructed to tap as fast as they could and were told that the period of time they were to tap was not of sufficient length to tire them. They were told to keep constantly in mind the point that they should try to increase their speed of performance. The length of the tapping period was ten minutes and a reading of the number of taps was made every ten seconds.

The subjects were tested singly, paired in competition with another, and alone but with a clock in front of them so they could tell how fast the time was passing. A whistle was blown as the starting signal and again ten seconds before the signal to stop. An interesting point is that instead of the performance speeding up after the whistle which would show on the work curve in the form of an 'end-spurt', there was almost the opposite effect in that most of the subjects tended to stop entirely. Athletes alone showed an 'end-spurt', probably due to their training.

Certain general results came from this study: first, that the motor ability of athletes seemed considerably above that of the rest of the group, including those with training in other lines; and second, the performance of those with training in other lines was considerably above that of the remainder of the group.

Competition seemed to have no appreciable effect of increasing motor performance; rather in many cases it seemed to decrease it probably due to a loss in steadiness and coordination. This seemed to be in line with the results obtained by Nakamura (34) who found that there was no significant difference between individual reaction time and reaction time in competition.

When the subjects tapped with the clock in front of them there was a noticeable increase in the motor performance. This agrees in general with the results of Book and Norvell (11) who found that knowledge of results intensified the goal and improved performance.

Later a study was made to see if tapping showed rhythms. Though evidence of rhythms did appear and remained during competition, the experiment was not continued because of the inadequacy of the apparatus.

Another study extending over a three year period was made of track performance to see if these showed rhythms. The group studied consisted of twenty-four middle distance runners including the average varsity candidates, the 'Big Six' and 'Big Ten' champions, and representatives of various athletic clubs some of whom were American and even world record holders. The athletes were tested in tryouts against time running by themselves but with the incentive of a possible trip, running time tryouts against their own team mates to determine the starters in the next meet, and finally in actual competition. This procedure was employed in order to discover if the degree of incentive had any modifying effect on the rhythms and also to find the effect of competition on the rhythms. These questions arose out of the larger question: Are the rhythms physiological? If these rhythms were purely physiological they should not be modified to such an extent by competition as they would be if they were of central origin.

The procedure was to take the time for each lap of the particular race studied and to plot the time curve. For the purpose of this experiment the half mile, 1000 yard, mile and two mile runs indoors and the two mile run outdoors were the only races investigated since these were the only performances giving a sufficient number of readings to plot curves in which rhythms might be discernable. The subjects with the exception of the writer did not know that they were being the subjects for any sort of experiment so that their performances are really their normal performances under the ordinary varsity track squad conditions and in no way influenced by this experiment.

Typical results from this investigation are presented in the following tables and figures.

RESULTS GATHERED FROM A STUDY OF TRACK PERFORMANCES

Kansas City Athletic Club Meet. 2/26/28. Convention Hall.

Kansas City, Missouri.

Table 1

1000 Yard Dash. Time 2:11 (New World's Record) Winner: Conger, Illinois Athletic Club.

LAP	TIME (for each lap)
1.	16.0
2.	18.0
3.	20.0
4.	18.0
5.	20.0
6.	22.0
7.	17.0

Table 2

880 Yards (Anchor man of the Iowa State 2 Mile Relay Team) Time 2:00

LAP	TIME (for each lap)
1.	16.0
2.	20.0
3.	19.0
4.	20.0
5.	23.0
6.	22.0

Table 3

880 Yard Dash. Time 2:03.5. Winner: Zeigler (University of Kansas)

LAP	TIME (for each lap)
1.	17.0
2.	22.0
3.	20.0
4.	21.0
5.	22.0
6.	21.5

RESULTS GATHERED FROM A STUDY OF TRACK PERFORMANCES

Kansas City Athletic Club Meet. 2/26/28. Convention Hall. Kansas City, Missouri.

Table 4

2 Mile Run. Time 9:31 (New Record). Winner: Shimek (Illinois Athletic Club)

LAP	TIME (for each lap)
1.	20.0
2.	22.0
3.	23.0
4.	22.0
5.	23.0
6.	23.0
7.	24.0
8.	24.0
9.	23.0
10.	26.0
11.	25.0
12.	26.0
13.	21.0
14.	24.0
15.	26.0
16.	25.0
17.	26.0
18.	25.0
19.	26.0
20.	24.0
21.	26.0
22.	24.0
23.	23.0
24.	20.0

RESULTS GATHERED FROM A STUDY OF TRACK PERFORMANCES

Kansas-Missouri Dual Meet. 3/2/28. Convention Hall. Kansas City, Missouri.

Table 5

880. Yard Dash. Time 2:03.6. Winner: Youngman (Kansas U.)

LAP	TIME (for each lap)
1.	18.6
2.	19.8
3.	21.6
4.	21.0
5.	20.8
6.	21.8

Table 6

One Mile Run. Time 4:27.2. Winner: Frazier (Kansas U.)

LAP	TIME (for each lap)
1.	21.4
2.	21.8
3.	21.6
4.	21.8
5.	22.4
6.	23.0
7.	23.0
8.	23.4
9.	23.2
10.	23.0
11.	21.2
12.	21.4

RESULTS GATHERED FROM A STUDY OF TRACK PERFORMANCES

Kansas-Missouri Dual Meet. 3/2/28. Convention Hall. Kansas City, Missouri.

Table 7

2 Mile Run. Time: 10:12.2. Winner: Frazier (Kansas U.)

LAP	TIME (for each lap)
1.	---- 26.0 (Sarvis)
2.	---- 26.0 (Sarvis)
3.	---- 28.0 (Sarvis)
4.	25.0 (Frazier)
5.	25.4
6.	24.6
7.	25.8
8.	25.2
9.	26.0
10.	25.6
11.	25.4
12.	27.0
13.	25.8
14.	22.2
15.	26.2
16.	24.8
17.	25.8
18.	29.2
19.	27.8
20.	26.0
21.	23.2
22.	25.8
23.	26.6
24.	18.8

RESULTS GATHERED FROM A STUDY OF TRACK PERFORMANCES

Tryout against time. 5/2/28. Kansas University Stadium.

Table 8

2 Mile Run. Time 10:02. Subject: Sarvis (Kansas U.)

LAP	TIME (for each lap)
1.	73.0
2.	77.0
3.	73.0
4.	77.0
5.	72.0
6.	76.0
7.	77.0
8.	77.0

Table 9

2 Mile Run. Kansas-Missouri Dual Meet 5/16/28. Time: 9:52.
Missouri University Stadium. Winner: Sarvis.

LAP	TIME (for each lap)
1.	72.0
2.	76.0
3.	72.0
4.	75.0
5.	71.0
6.	75.0
7.	76.0
8.	75.0

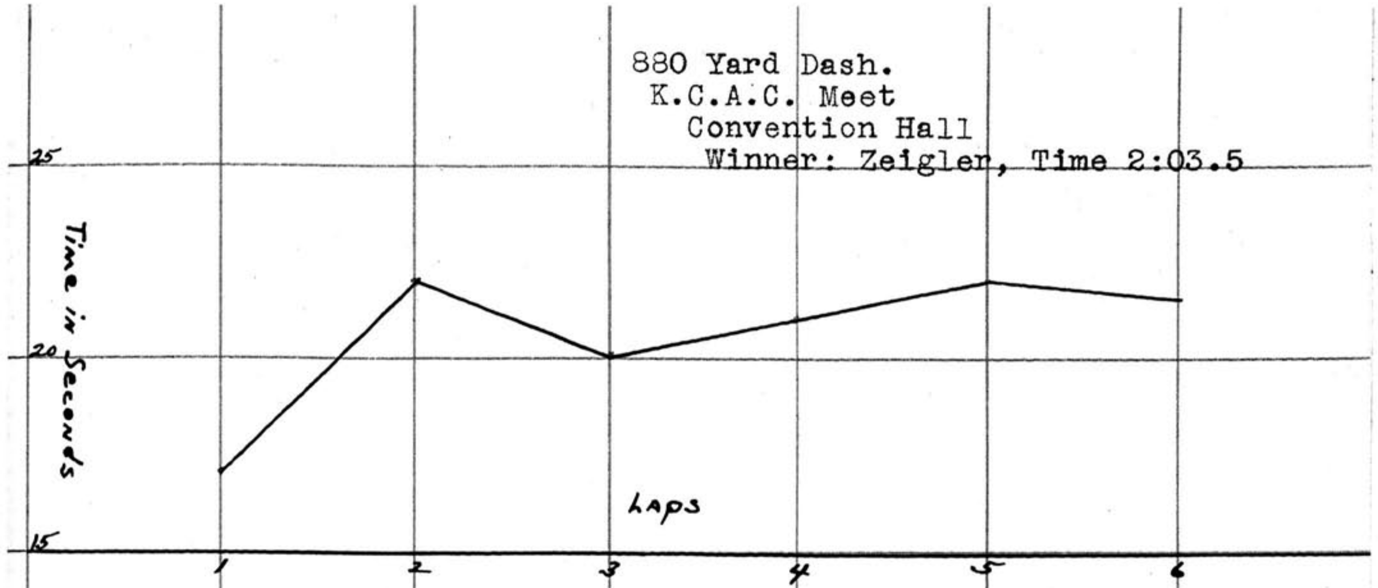


Figure 1.

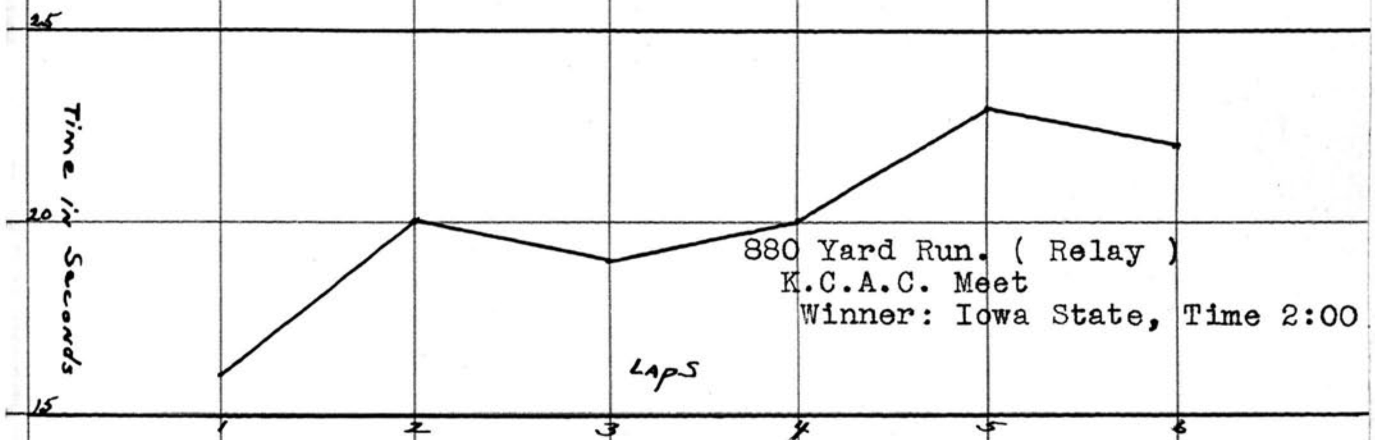
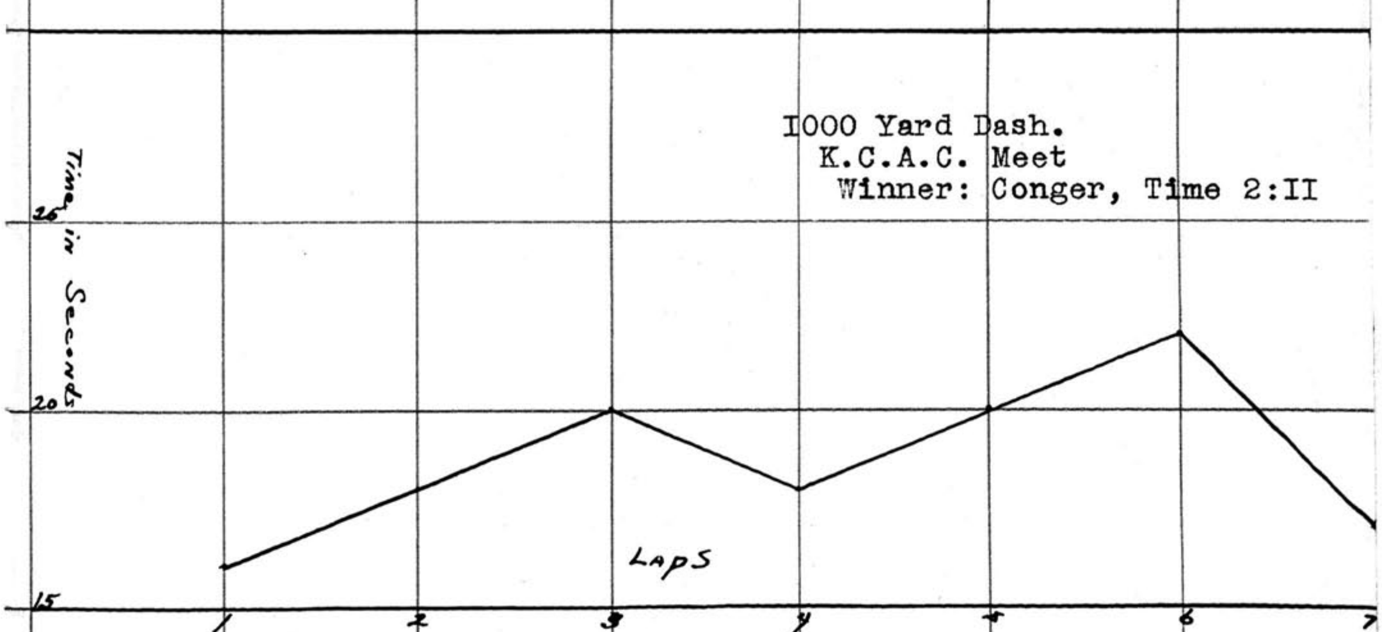


Figure 2.



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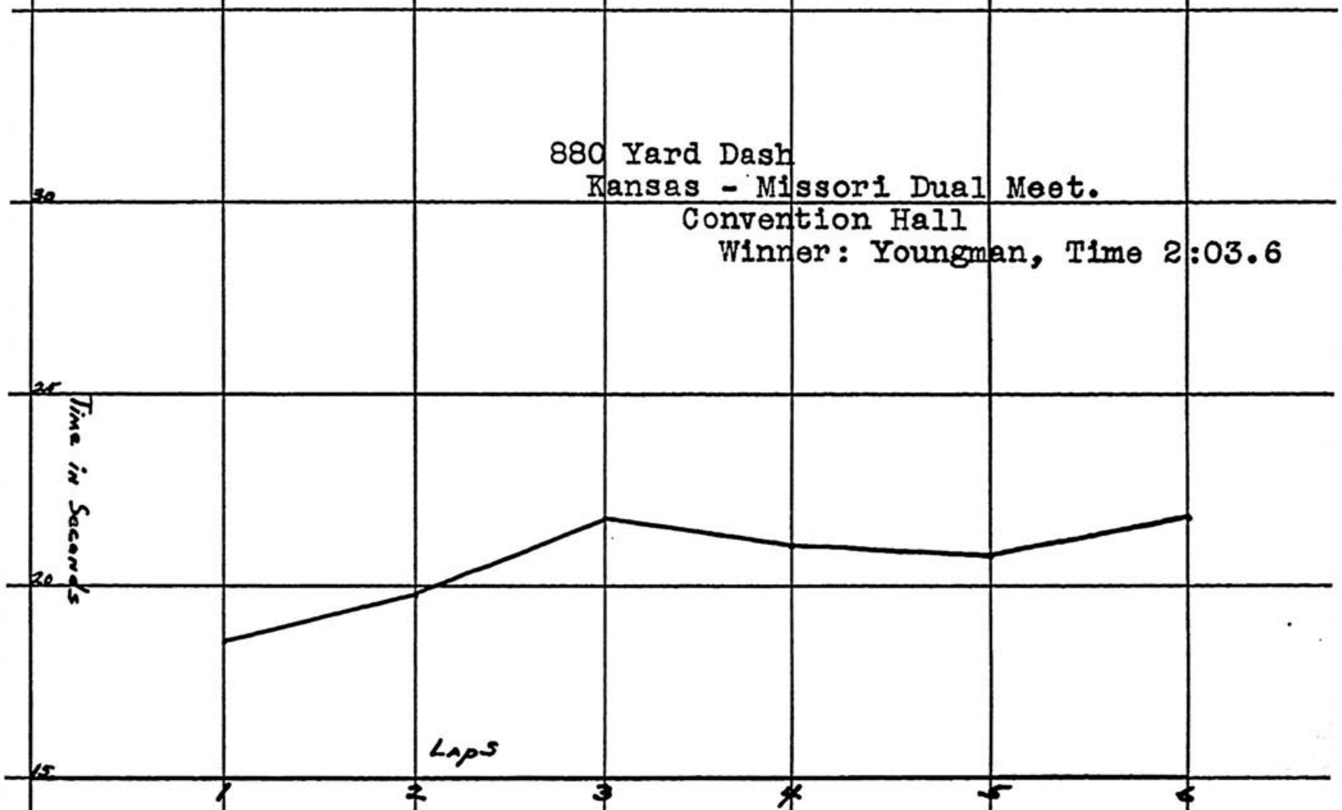

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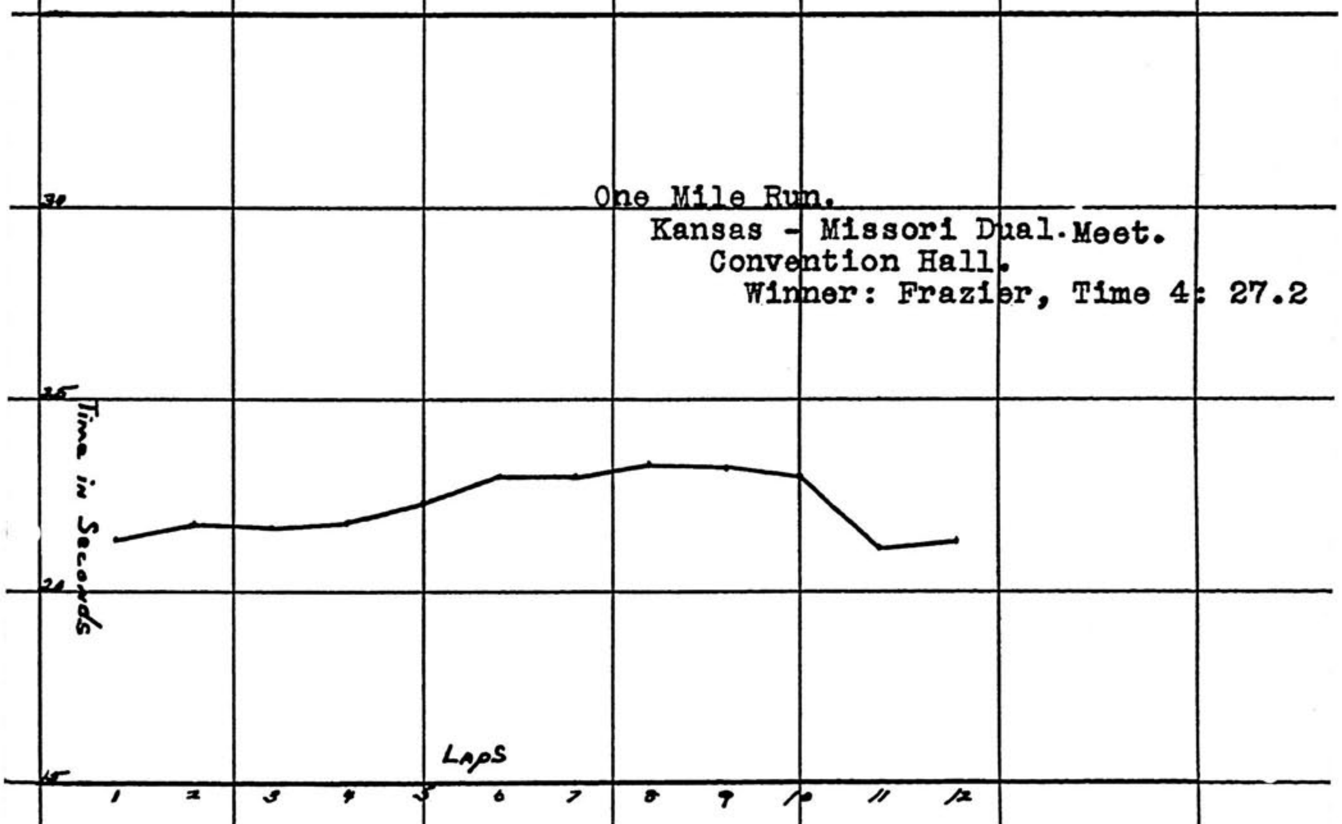
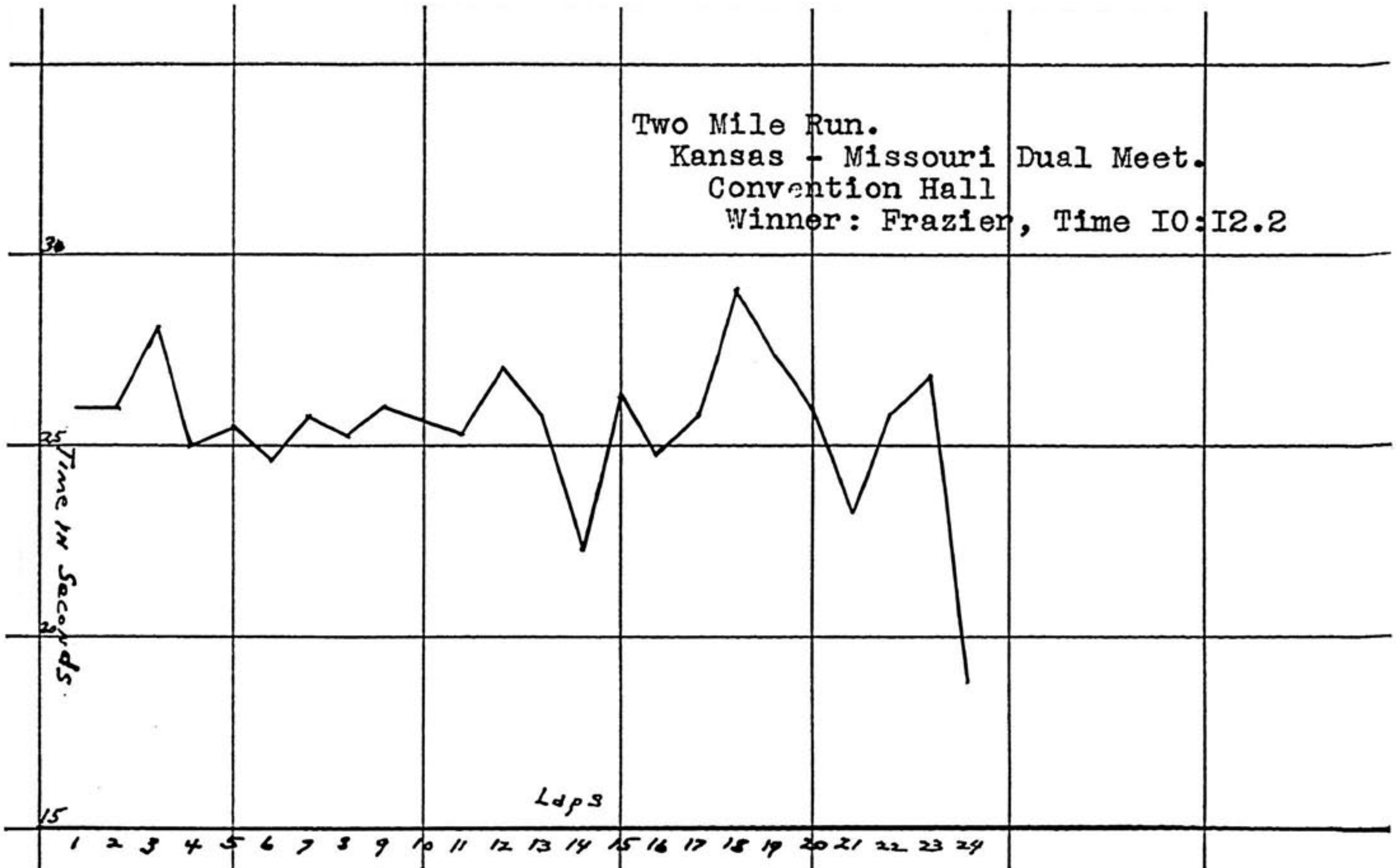


Figure 5.



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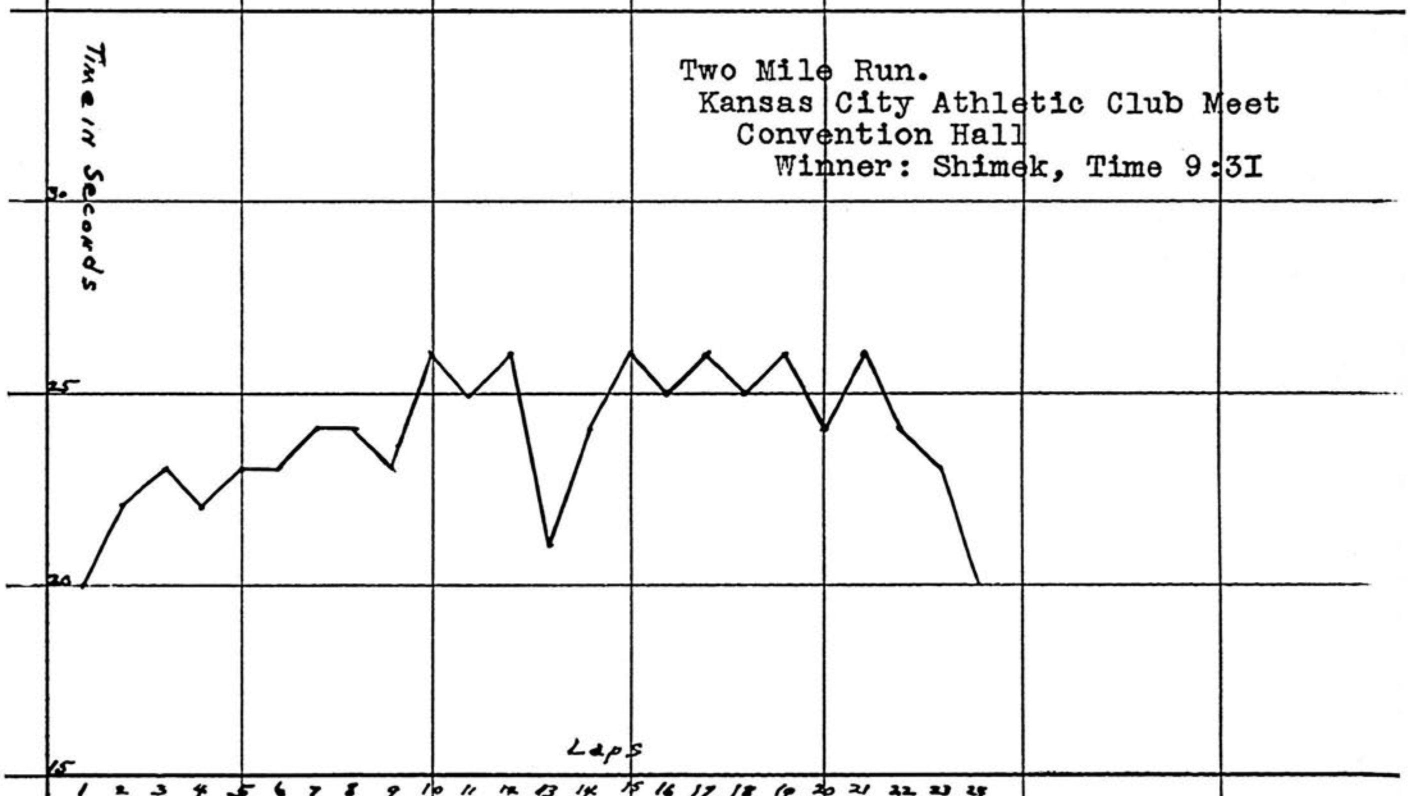


Figure 7.

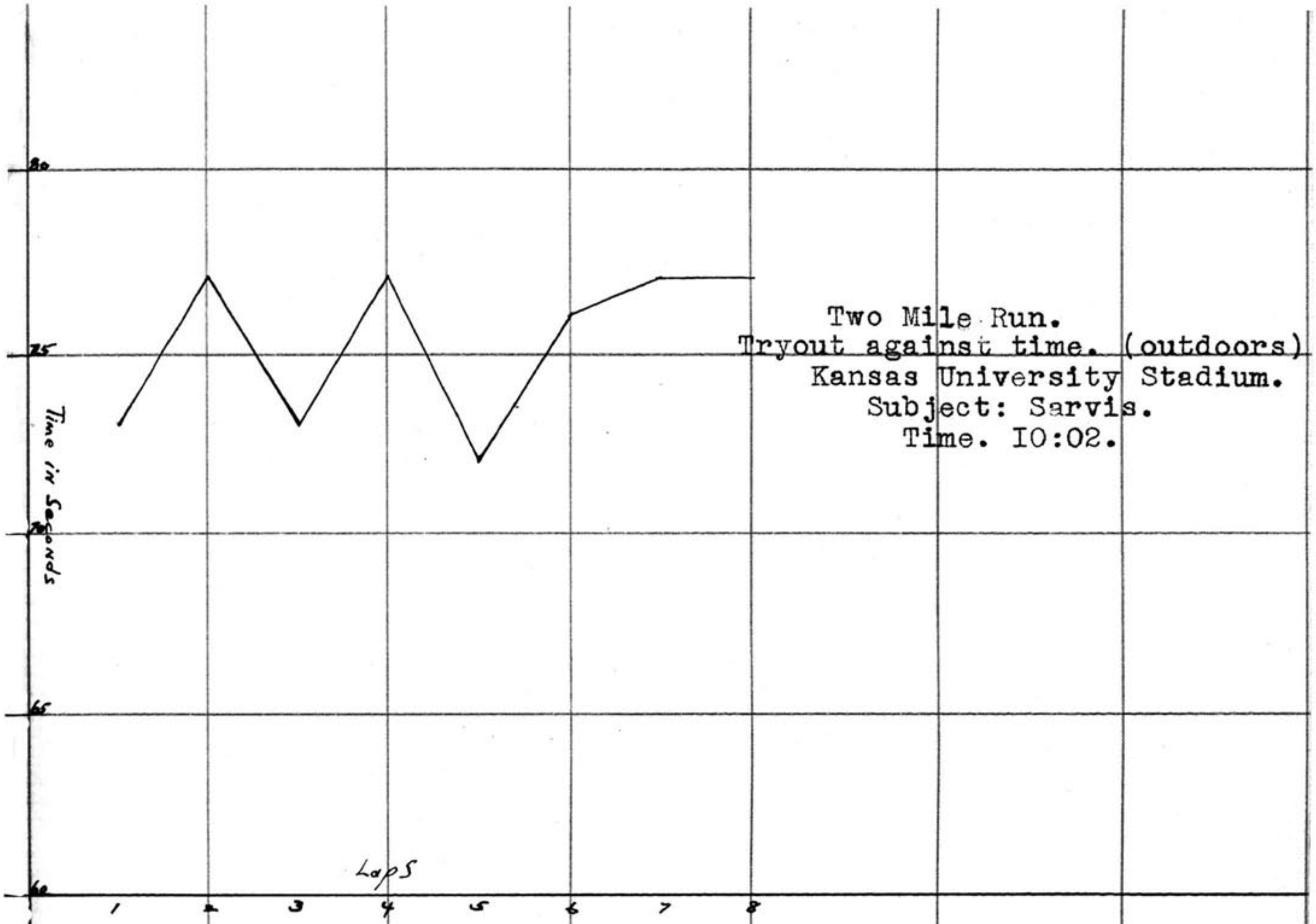


Figure 8

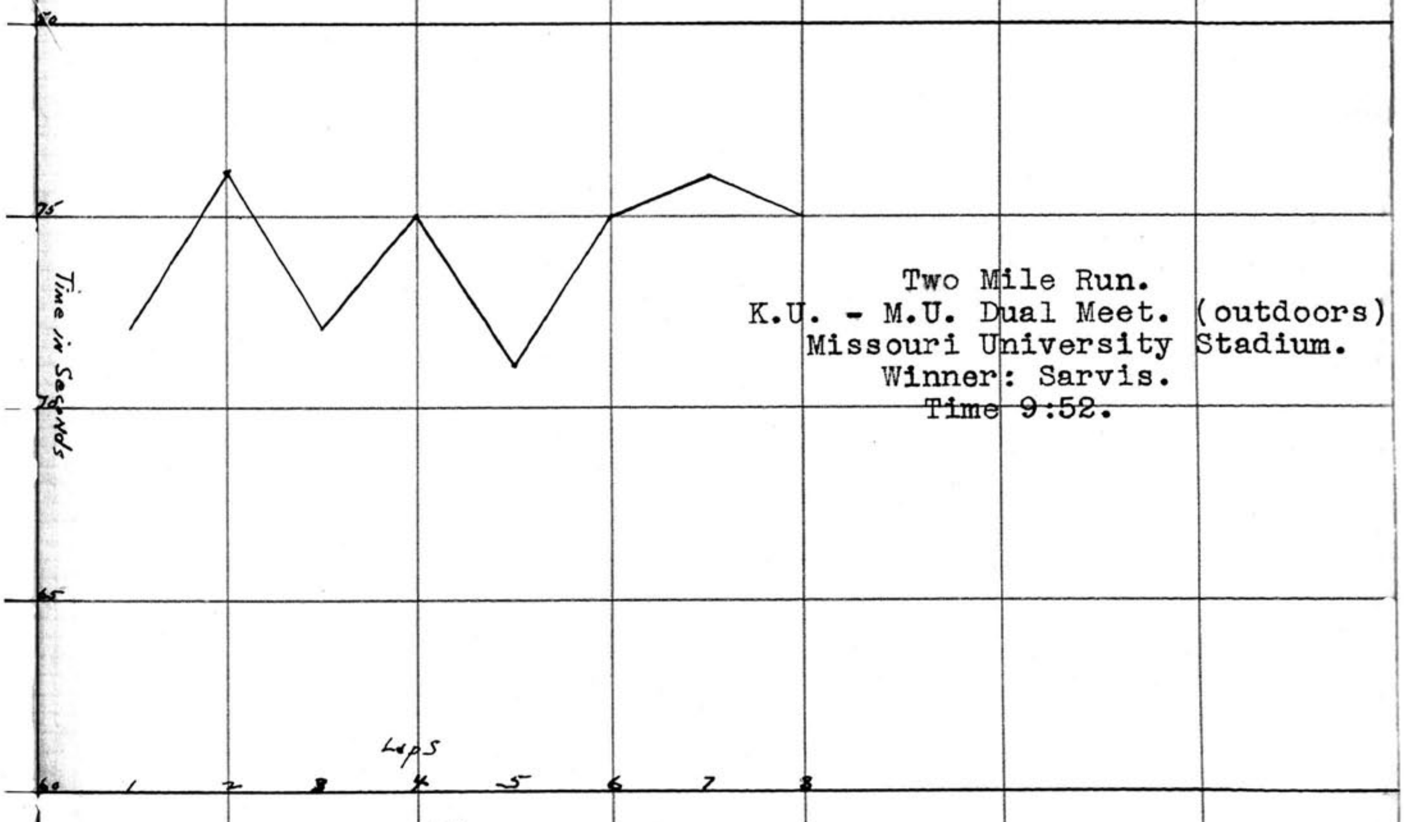


Figure 9.

The 1000 yard dash in the Kansas City Athletic Club Meet shows in the time curve (Table 1 and Fig. 3) striking evidence of rhythms. We find first a fast lap (16) than a slow one (18) and then a slower lap (20) then a fast one again (18) then a slow one (20) and then a slower one again (22) and then a fast one. There is a rhythmical increase in the time curve -- 2 seconds, 2 seconds, 2 seconds and a drop, then 2 seconds, 2 seconds, 2 seconds and a drop. It is believed that if the subject had run two more laps we would have found next two high points on the curve just preceding another drop in the time curve.

In the time curve of the anchor man of the Iowa State 2 mile relay team (Table 2 and Fig. 2) rhythms appear, though not as striking. We find first a fast lap (16) then a slow lap (20) with the next lap being faster than the second though not as fast as the first (19). The next part of the curve shows a fast lap (20) then a slow lap (23) with the next lap being faster than the fifth, though not as fast as the fourth (22). Here we find both halves of the curve exhibiting the same form though the level of the curve is changed.

The time curve for the winner of the 880 yard dash in the Kansas City Athletic Club Meet, (Table 3 and Fig. 1) shows almost the same form as the preceding curve though it differs in the general level of performance. We find first a fast lap (17) then a slow lap (22) then the next lap faster than the second though not as fast as the first (20). The next part of the curve shows a fast lap (21) then a slow lap (22) with the next lap being slightly faster than the fifth lap though not as fast as the fourth. Both halves of the curve show the same form.

The time curve of the 2 mile run in the Kansas City Athletic Club Meet, (Table 4 and Fig. 7) shows evidence of a rhythmic pattern. We find a trend upward in the time curve until the thirteenth lap where a sudden drop is seen (this is one lap beyond the center of the curve). The next part of the curve shows a rise until near the end of the race where we find a gradual drop with the last lap showing a more pronounced drop. Here the major rhythms appear to be 13 laps and 11 laps.

The 880 yard dash in the Kansas-Missouri Dual Meet shows the same phenomenon in the time curve (Table 5 and Fig. 4). We find first a fast lap (18.6) then a slow lap (19.8) then a slower lap (21.6) with the next lap (21.0) being faster than the third though not as fast as the second or first. In the rest of the curve we find first a fast lap (20.8) and then a slow lap (21.8). If the curve were continued it is thought that we should find a lap which was slower than the sixth and then a lap which would be faster than the seventh though not as fast as the sixth.

In the mile run in the Kansas-Missouri Dual Meet (Table 6 and Fig. 5) we do not find very definite patterns of rhythms, but it does appear that the first five laps may be grouped together as one part of the pattern. We believe the last two laps are the beginning of another pattern of five.

On the 2 mile run in the Kansas-Missouri Dual Meet, (Table 7 and Fig. 6) we also find some evidence of rhythmic patterns. The first three laps must be thrown out as the subject was trying to stay behind in order that his team-mate might win the race. Seeing that his team-mate could not win he went out and took the lead. We find a slight trend upward until the fourteenth lap where we find a sudden drop (this point is two laps beyond the center of the curve). In the next part of the curve there is a general trend upward until the last lap where there is a sudden drop. The subject's major rhythms appear to be 14 laps and 10 laps. An interesting point in the light of this study is the similarity between the time curve for this race and the curve shown in Figure 7 for the 2 mile run in the Kansas City Athletic Club Meet, in which Frazier, the runner in this race, ran almost neck and neck with the winner, Shimek, until the twenty-second lap, so we may consider the curve to that point as being Frazier's as well as Shimek's. We find that although the runner, Frazier, had already won the mile run and was probably quite tired his curve of performance was similar in form though not in amplitude to his curve of performance when he ran only the 2 mile run the week before.

The time curve for the 2 mile tryout (outdoors) (Table 8 and Fig. 8) shows very striking rhythmic pattern. We find a fast lap (73) then a slow lap (77) then a fast lap (73) then a fast lap (73) then a slow lap (77) then the fastest lap (72) then a slow lap (76) then two laps (77) (77). The pattern seems to be up 4 seconds, down 4 seconds, up 4 seconds, down 5 seconds, up 5 seconds, up 1 second, and the last lap remains the same as the preceding lap.

The time curve for the 2 mile run in the Kansas-Missouri Outdoor Dual Meet (Table 9 and Fig. 9) also shows distinct evidence of rhythms. We find a fast first lap, (72) then a slow lap (76) then a fast lap (72) then a slow lap (75) then a fast lap (71) then a slow lap (76) with the last lap being slightly faster than the preceding lap. The pattern seems to be up 4, down 4, up 3, down 4, up 5, and down 1. The form of the curve is almost exactly the same as that for the 2 mile tryout shown in Figure 8 though the race was two weeks later. The slight difference in the last part of the curve and the difference in the amplitude of the curve are probably due to the competition. In both cases the fifth lap was the fastest lap in the race. Effort on the part of the subject to change this factor always resulted in a general lowering of the level of efficiency of the whole performance.

From a study of the curves there seems to be very good evidence of motor rhythms in track performance. The curves show patterns which are repeated in succeeding parts of the curve. These patterns are so regular that after considering two of them we are able to predict the high and low points of the forthcoming performance with almost mathematical certainty. These rhythms seem to persist over a considerable period of time as is shown by the fact that the runners seem to exhibit the same rhythms throughout a whole season of varsity competition.

The rhythms depend of course on the length of the training period of the subject, for if his training period has been too short the pace may remove him from the race before he has had a chance to exhibit any rhythmic pattern. It depends also to a very great extent on the physical state of the runner at the time of his performance, for if he is at a low point physically there will be an appreciable diminution in his performance and the general level of the curve will be raised.

Competition, while it does have some effect on the performance of the subject as shown by a drop in the amount of time required for the completed performance, seems merely to lower the general level and not the general pattern of the curve.

As a result of a rather general study of the performances of track athletes extending over a period of three years it appears that each individual has a certain type of race which he must run in order to obtain the maximum efficiency in his activity. Some individuals run a fast first part, a slow middle part, and a fast last part; others a slow first part, a fast middle part and a slow last part; still others seem to run a slow first and a fast last half; some run at a relatively constant pace throughout the entire race. The subjects seemed to have the same type of race regardless of whether they ran the half-mile, mile or two mile runs. When an individual attempts to run a type of race different from his usual pattern he finds that changing any one part of his performance will raise the general level of the time curve. In order to run the best race possible the coaches tell their athletes to run their own race and not to be too much influenced by the pace of the man with whom they are running. This is a simple way of saying that to get maximum efficiency a runner must follow his own rhythmic pattern and not that of his competitor.

MAZE

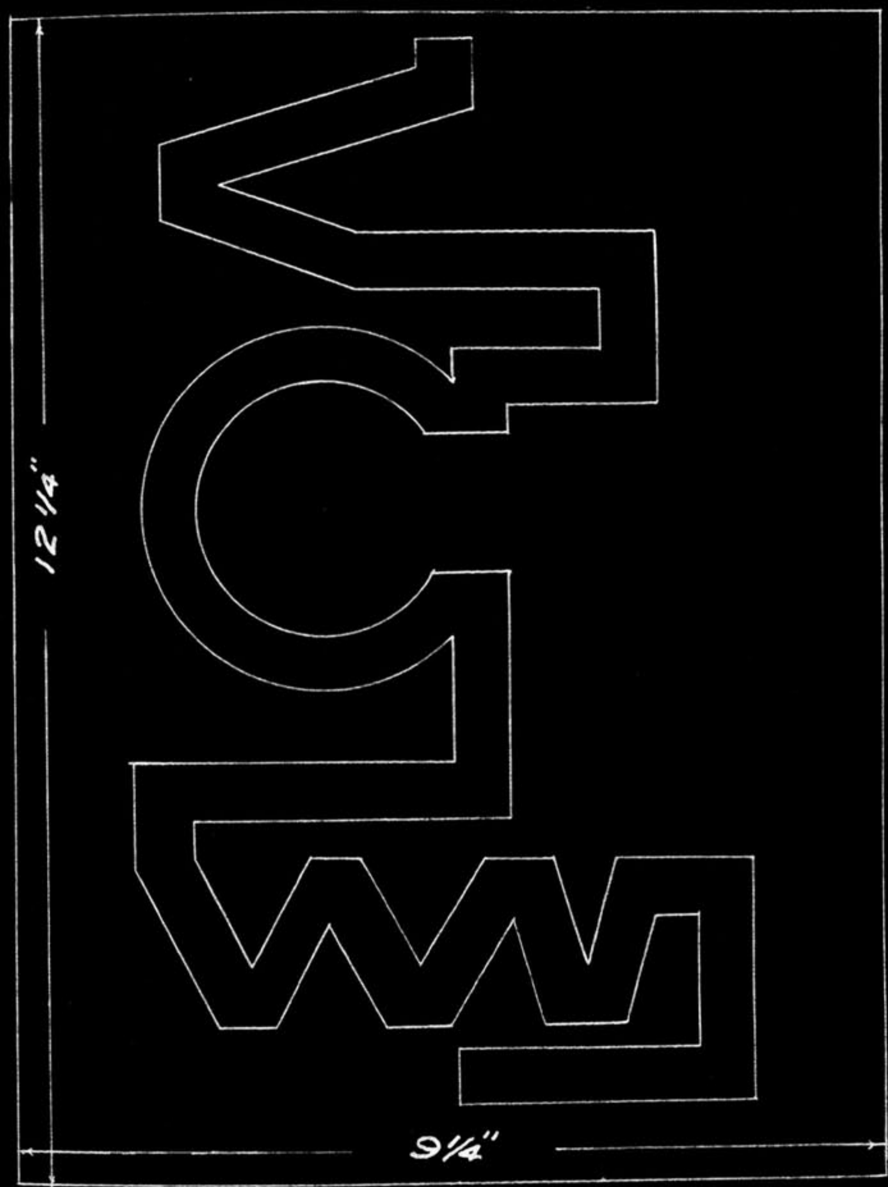


Figure 1

IV. GENERAL PROBLEMS

Wheeler's Original Study

Wheeler began in 1923 at the University of Oregon a study of the periodicity of performance. His procedure consisted in having subjects trace a simple maze while blindfolded. The subjects were required to trace the maze as rapidly as possible for a period of two hours, no time being allowed for relaxation. The time curves showed striking periodicities of performance.

The study was later carried on at the University of Kansas from 1924 to 1931. The writer served as observer for Wheeler from 1927 to 1929, and from 1929 to 1931 pursued the problem independently under modified conditions.

The subjects were undergraduate students at the University of Oregon, and undergraduate and graduate students at the University of Kansas. Approximately thirty subjects were investigated at the University of Oregon and one hundred subjects at the University of Kansas.

The apparatus (Figure 10) consisted of a brass maze with outside dimensions of nine and one quarter inches by twelve and one quarter inches. This maze contained no culs de sac but did have small niches cut in the grooves. A stylus and a pair of goggles were also provided for each subject.

The following instructions were given: Before you is a maze or labyrinth which you are to learn to trace as rapidly as you can, but also as accurately as you can. By accuracy is meant the extent to which you are able to avoid getting caught in the sides of the groove, which are niched. You are to begin at the point to which I shall guide your hand and start when I say 'Go'. You are to keep going as rapidly as possible until you come to the end. I will tell you when you reach this point. Then you are instantly to retrace the path back to the starting point again. I will also tell you when you reach this point. Then I shall take your time; but, without stopping, you are to continue to thread the maze back and forth as rapidly and as accurately as you can. When you reach the starting point I shall again record your time. This procedure will be continued for two hours. Nevertheless, you are to do the best that you can, every time you make the circuit. You are not to stop and rest until I tell you to. Remember that your object is efficiency in learning to trace the maze with all possible speed. It is not a mental test of any kind. You will be shown your results and the maze when you are finished.

Repetition of Wheeler's Study

The present independent study of rhythms followed in general the same procedure as the original work of Wheeler; the same apparatus was used, but the instructions and methods were slightly modified. The subjects were nine undergraduate students and one senior member of the staff.

The following specific problems were attacked by various methods. The main problem concerned the persistence of the rhythms over a period of time, and the extent to which the rhythmic pattern underwent modification. In order to investigate this problem the subjects ran the maze once a week for a period of from three to five weeks. Second, do the work curves show any evidence of 'initial' or 'end-spurts'. This problem was investigated by telling the subjects the time every minute for the first fifteen and last ten minutes of the experiment, and at ten minute periods throughout the experiment. Third, is there any relation between increasing efficiency in tracing the maze and the accuracy of the visual image as shown by the drawings. Subjects were asked to draw the maze as well as they could after each completed period. Fourth, is there any relation between the length of the experimental period and the length and amplitude of the rhythmic pattern. This was studied by varying the length of the experimental period from one half hour to two hours, some subjects tracing two hours; others tracing one hour; and still others for only half an hour. Fifth, is direct visual perception of the maze pattern correlated with appreciable improvement in motor efficiency. The half hour subjects first traced the maze blindfolded but on their second trial they were shown the maze before they started to trace it. Sixth, do the subject's introspective reports throw any light on the significance of the rhythmic pattern for that particular subject and trial. To get at this problem the subjects were asked at the end of each experiment to report on the direction of most rapid progress, and on the difficult and easy portions of the maze pattern. They were asked also to introspect freely at any time during the course of the experiment. Seventh, is there any relation between the degree of incentive and effort and the level and form of the rhythmic pattern. This problem was studied by comparing the work curves of subjects whose incentives probably differed. Some of these subjects offered their services out of friendship for the experimenter, others from the viewpoint of scientific interest, others to make up absences in general psychology classes and to raise their grades, and still others served as paid subjects.

In the present study in order to avoid averaging and to see whether the maze pattern offered any differences in difficulty in going over and in coming back, the time was taken from the starting point to the end and from the end to the starting point, and not from the starting point back to the starting point as in Wheeler's study.

The following instructions were given: Before you is a maze which you are to learn to trace as rapidly as you can, but also as accurately as you can. By accuracy is meant the extent to which you are able to avoid getting caught in the sides of the groove which are niched. You are to begin at the point to which I shall guide your hand and start when I say "Go". You are to keep going as rapidly as possible until you reach the end. I will tell you when you reach this point. Then you are instantly to retrace your path back to the starting point. I will also tell you when you reach this point. I shall take your time from the moment you leave the starting point until you reach the end and from the moment you leave the end until you are back at the starting point; but without stopping you are to continue to thread the maze back and forth as rapidly and as accurately as you can. This procedure will be continued for two hours. (For the one hour and half hour subjects the proper time was inserted in the instructions.) Nevertheless you are to do the best that you can every time you make the circuit. You are not to stop and rest until I tell you to. Remember that your object is efficiency in learning to trace the maze with all possible speed. It is not a mental test of any kind. At the conclusion of the experiment you will be asked to draw as well as possible your visual image of the maze and to indicate on the drawing the parts of the maze which gave you the most difficulty, and those parts which were easiest. You will also be asked to tell in which direction, going over or coming back, you think you made the most rapid progress. You are to introspect freely during the course of the experiment as to feelings of fatigue and rested periods, and as to any changes in the difficulty of the maze and in it's pattern. At the end of the final trial of the experiment you will be shown your results.

A Study of Periodicity without Learning

Since the tracing of the maze mentioned above definitely involved learning, an even more simple apparatus was used: a square tracing board with outside dimensions two feet by two feet, which had smooth grooves and a diagonal up the center (Figure 11). To prevent the subjects from losing the stylus and thus losing time in tracing as they had in the maze tracing, overhanging tracks and a special stylus were used. A pair of goggles was provided for each subject. The subjects were ten undergraduate students who performed the experiment once a week for a period of four weeks.

The following specific problems were investigated by various methods. First, do the work curves obtained from the square tracing board, in which learning is not involved, reveal rhythmic patterns. The regular repetition of similar patterns in the time curve was taken as evidence of the existence of rhythms. Second, do these rhythms persist over a period of time. To test this point the subjects were required to perform the experiment once a week for four weeks. Third, is there relation between the subjects' introspective reports of feelings of fatigue and rested feelings, and motor efficiency at the time. Fourth, how does the general pattern of rhythms in non-learning performances compare with the pattern in perform-

SQUARE TRACING BOARD

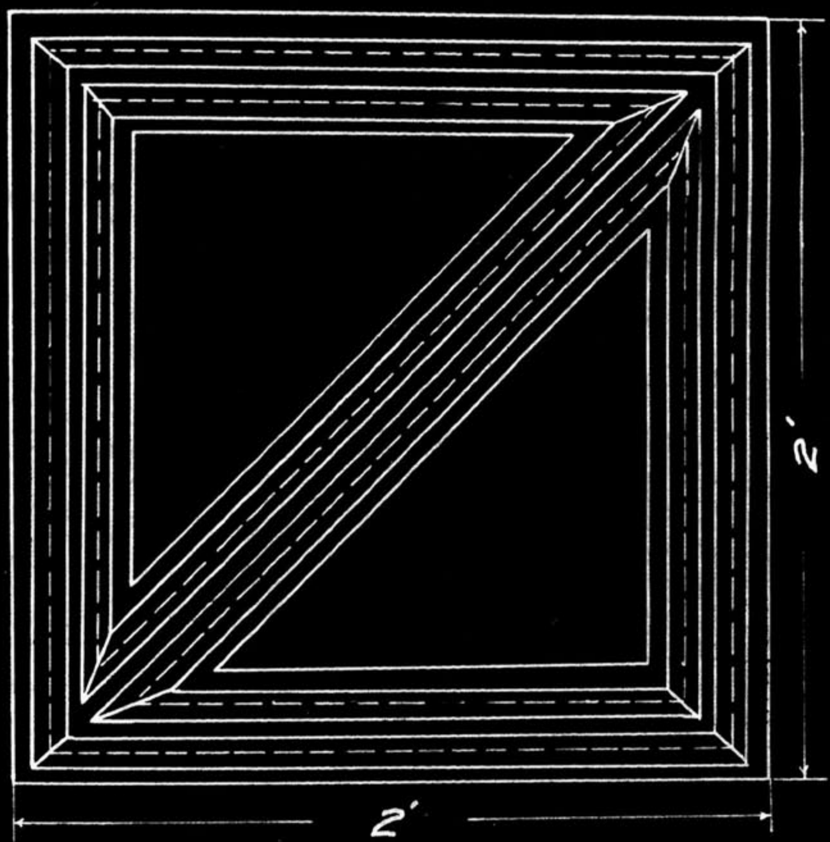


Figure 11

ances which involve learning. Rhythms obtained in the repetition of Wheeler's study were compared with those obtained in the present study.

The following instructions were given: Before you is a square tracing board (the subjects were shown the tracing board before the experiment began) which you are to trace as rapidly as you can. You will trace twice around the square and then once around the triangle formed by the diagonal and the two sides. You are to keep constantly repeating this procedure for half an hour. Remember your object is to trace the pattern as rapidly as possible. You are to report throughout the process of the experiment every time you feel fatigued and when you again feel rested. You are also to introspect freely throughout the course of the experiment.

V. EXPERIMENTAL RESULTS

Technique

Since the subject of rhythms in simple motor performances has been studied only recently there is no absolute technique as yet devised to demonstrate statistically the existence of these rhythms. In order to understand the results of this experiment it will be necessar, for us to present the technique employed in the present study. The technique employed was that used by Wheeler (58) with certain modifications which seemed necessary during the course of the present study.

A careful study of the curves of work obtained in this experiment revealed several characteristics which give significance to these rhythmic patterns. One of these is major slants which are slopes from a high point to a low point, and from this low point to a new low point; another, major curves which are rhythmic patterns containing high points at both the beginning and the end; a third, major resting places which are places where the subjects seem to have reached a so-called 'plateau of performance', in which the time for several trials was the same.

In examining the curves they were viewed as a whole. Isolated high and low points were not the only points of significance; instead tendencies toward maxima and minima were emphasized. The major high points are very important for in many cases they are nine times the standard deviation.

In this study a rhythm was arbitrarily defined, for the sake of uniformity, as the repetition of similar patterns in succeeding parts of the time curve.

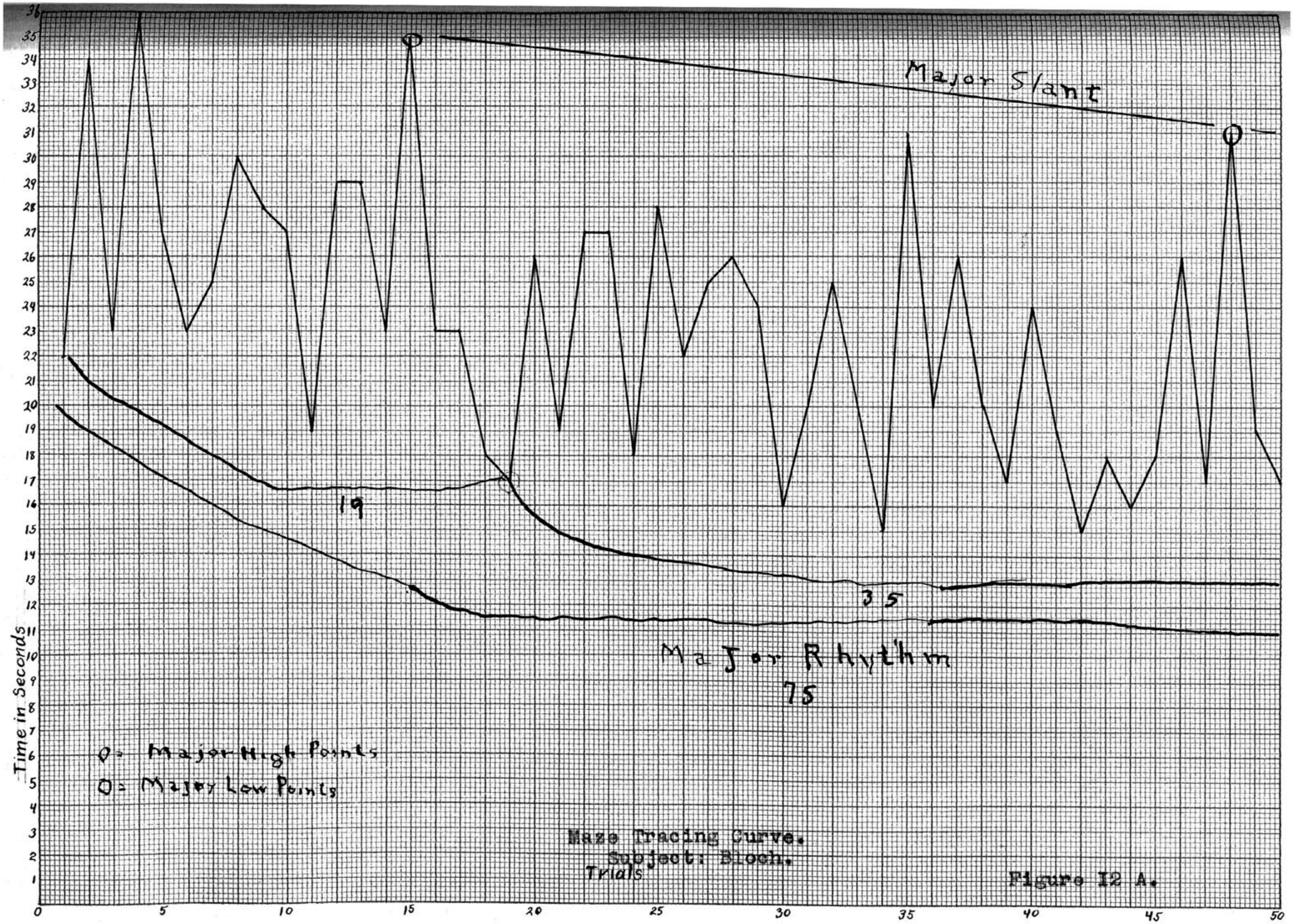
In defense of this technique we offer the following: first, as yet no definite technique has been developed, hence we choose this method as a working basis; second, the results obtained by using this method can hardly be attributed to chance since we find the same phenomenon in approximately all the one hundred and fifty or more subjects examined during the course of the experiment; third, the method is quite satisfactory in that it enables us to predict the high and low points of the subjects' forthcoming performance from a study of the first two or three rhythms discovered.

Wheeler's Original Study

The Existence of Rhythms

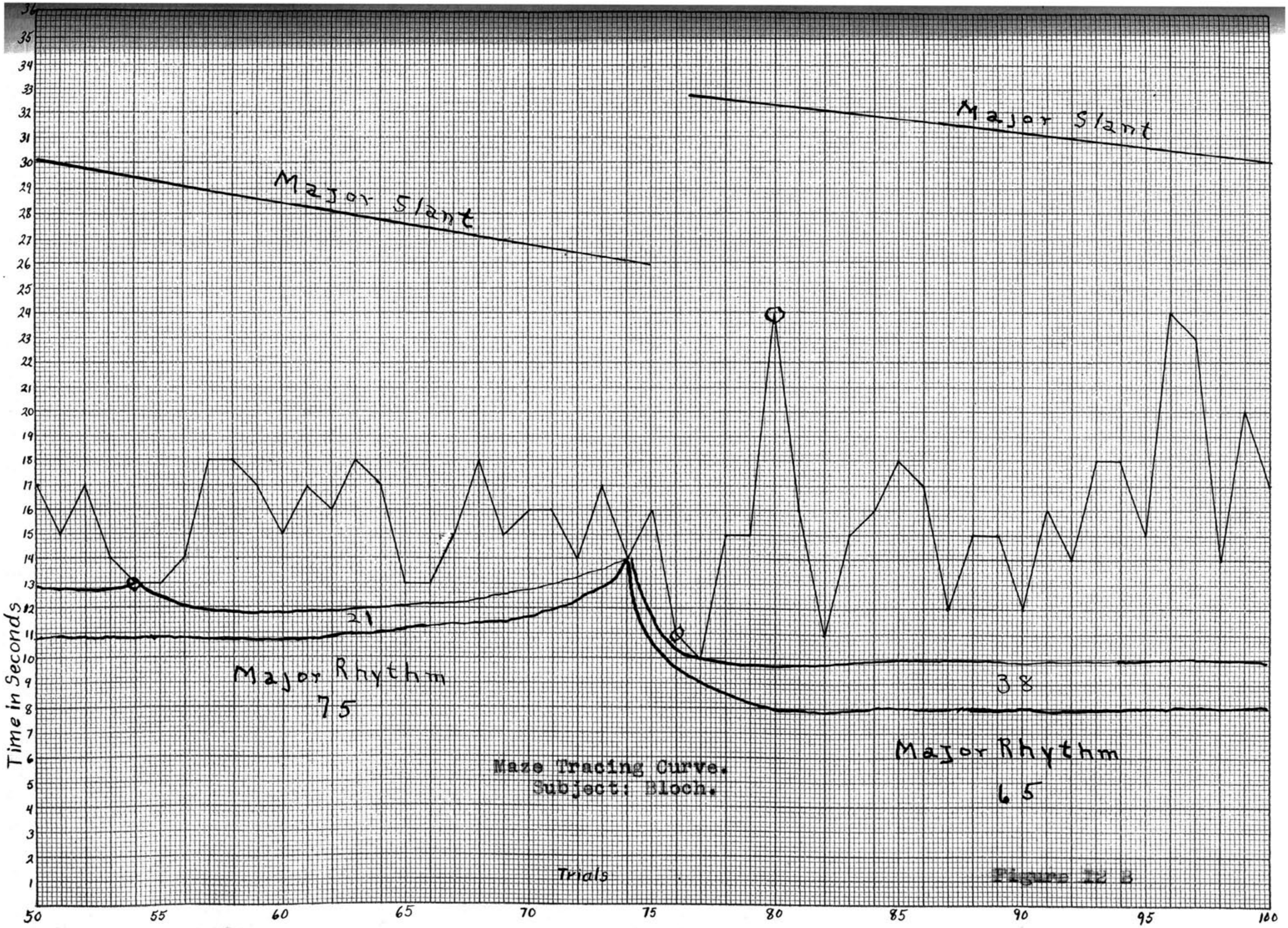
We find that all the subjects in Wheeler's original study show definite rhythms in their performances. Waves were found of approximately equal length and characteristic form. These rhythms were so regular that after examining two or three of them it was possible to predict the high and low points in the forthcoming trials with almost mathematical certainty. The rhythms tend to maintain the same length throughout the curve of learning for that particular trial. There is only an occasional tendency to shorten and when the rhythmic pattern shortens it does so by only the amount of a phase of a minor rhythm. The curves showed major rhythms of approximately equal length and these major rhythms in turn showed minor rhythms. Each major rhythm seemed to have the same number of minor rhythms except at such times when the rhythmic pattern tended to shorten by the extent of a phase of a minor rhythm as the learning process progressed. These minor rhythms in turn seemed to be broken up into smaller rhythmic patterns which we called phases of the minor rhythm. Though these phases might differ from rhythm to rhythm they showed a fairly regular order in the pattern of their alteration.

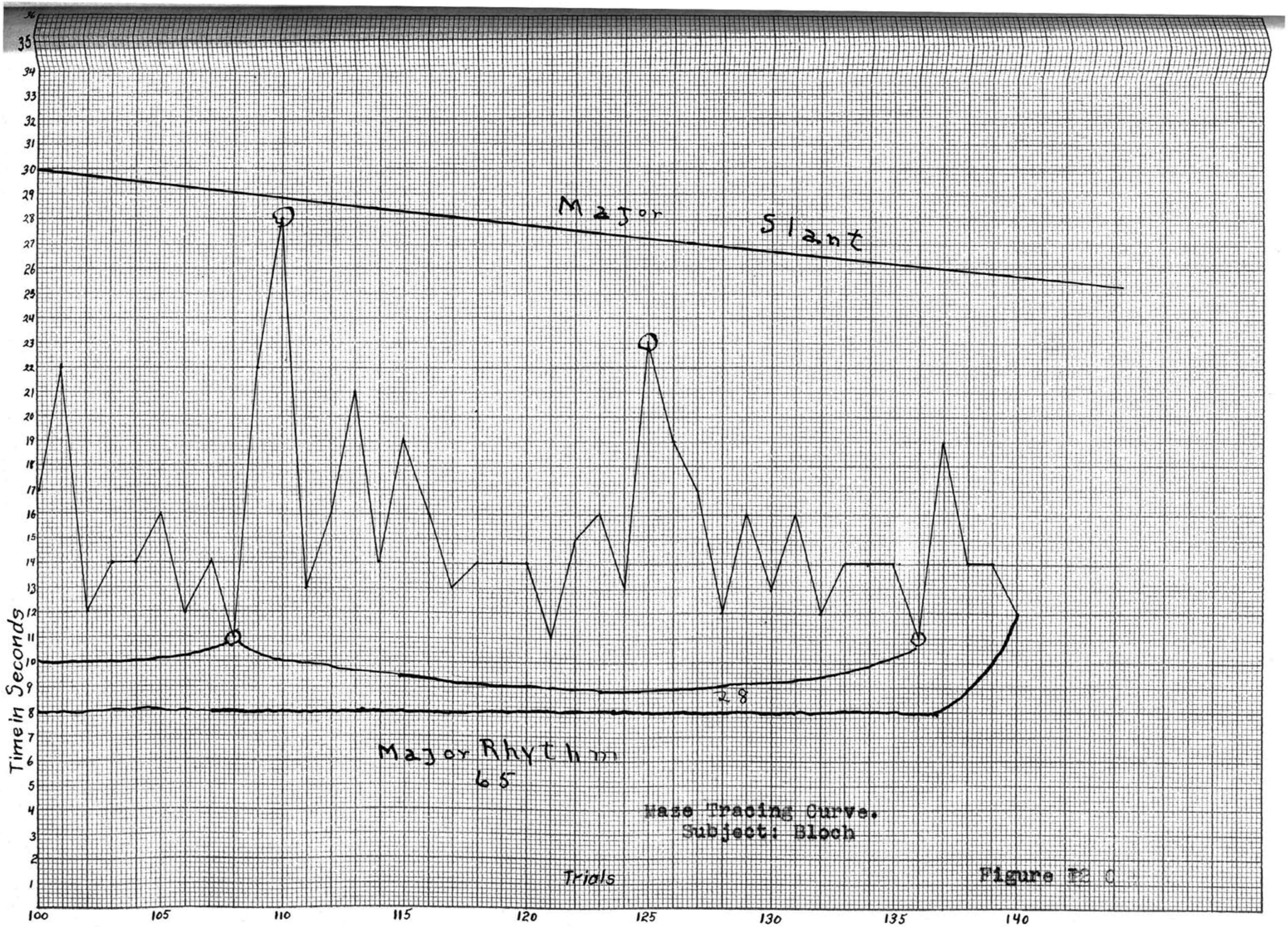
The work curve of subject Bloch (Figure 12) shows



Maze Tracing Curve.
Subject: Bloch.

Figure 12 A.


Time in Seconds
Trials
Major Slant
Major Slant
Major Rhythm
75
21
Major Rhythm
65
38
Maze Tracing Curve.
Subject: Bloch.
Figure 12 B



Maze Tracing Curve.
Subject: Bloch

Figure [illegible] C

these rhythmic patterns very definitely.

The total number of completions of the maze pattern is 140.

The major slants are as follows: from trial 1 to trial 75 (75 trials) and from trial 75 to trial 140 (65 trials). We believe that if the subject had continued the experiment for a longer period we should have found at approximately trial 150 a point lower than the point at 140 and this would make the major slants 75 and 75. If we disregard the first ten trials when the subject was orienting himself to the problem we would get major slants of 65 and 65.

Disregarding the first ten trials when the subject must be considered as orienting himself to the maze pattern we find major high points at 15, 48, (33) 80, (32) 110, (30) 127, (27).

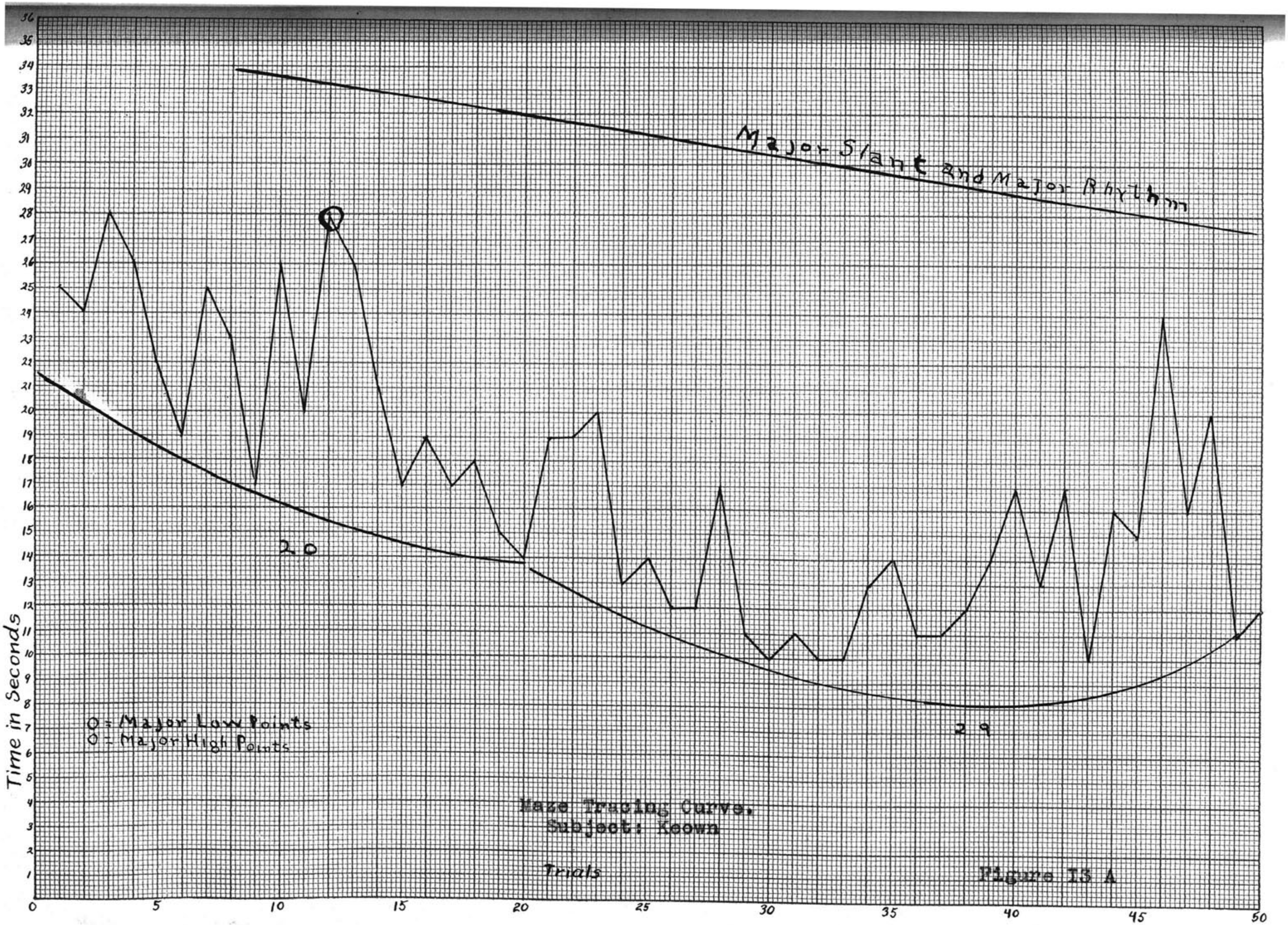
The major low points occur at 19, (19) 54, (35) 75, (21) 108, (38) and 136, (28).

On the basis of the major slants we may say that the subject has major rhythms of 75 and 65. (If we disregard the first ten trials where the subject was becoming oriented to the maze pattern we find major rhythms of 65 and 65.) The subject shows a progressive decrease in the frequency of major high points as the learning progresses. This is in line with the work of Bills (8) who found that in mental blocking practice tends to make the peaks occur less often. The major low points also show a decreasing frequency which may be due to stabilizing of the energy pattern. In the minor rhythms there is a regular alternation of long and short patterns; short (19), long (35), short (21), long (38) and short (28). The minor rhythms all seem to have the same number of phases. Two phases appear in each though these phases differ in their extent.

In the work curve of subject Keown (Figure 13) we also find definite rhythmic patterns.

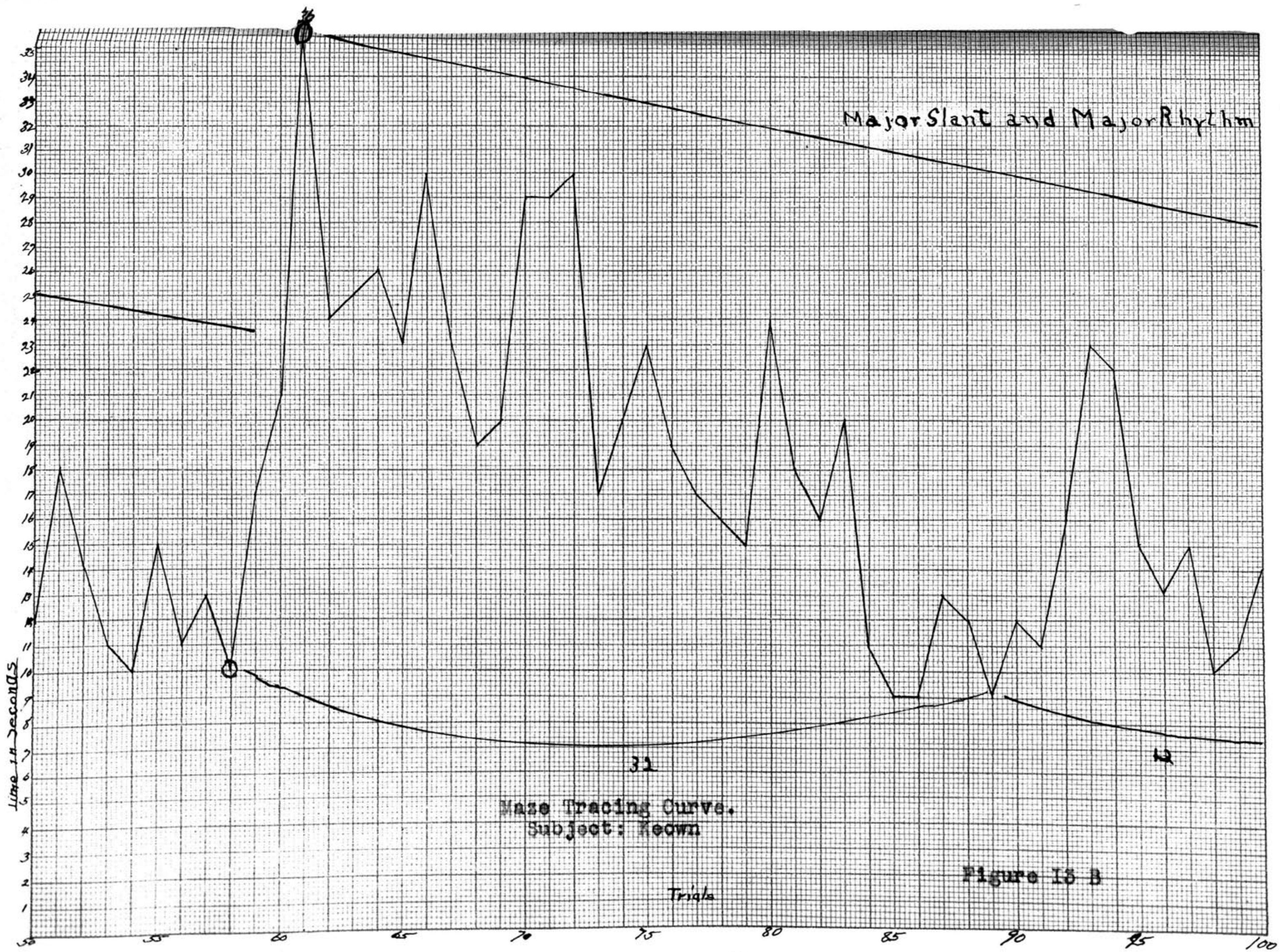
The total number of completions of the maze pattern is 130. Disregarding the first ten trials when the subject was becoming oriented to the maze pattern we find major slants from 10 to 58 (48), and from 58 to point 102 which is the low point before the major high point (44). The major high points seem to be at 13, 61, (48), 106 (45). Major low points appear at 58 (48 due to omission of the first ten trials) and 102 (44).

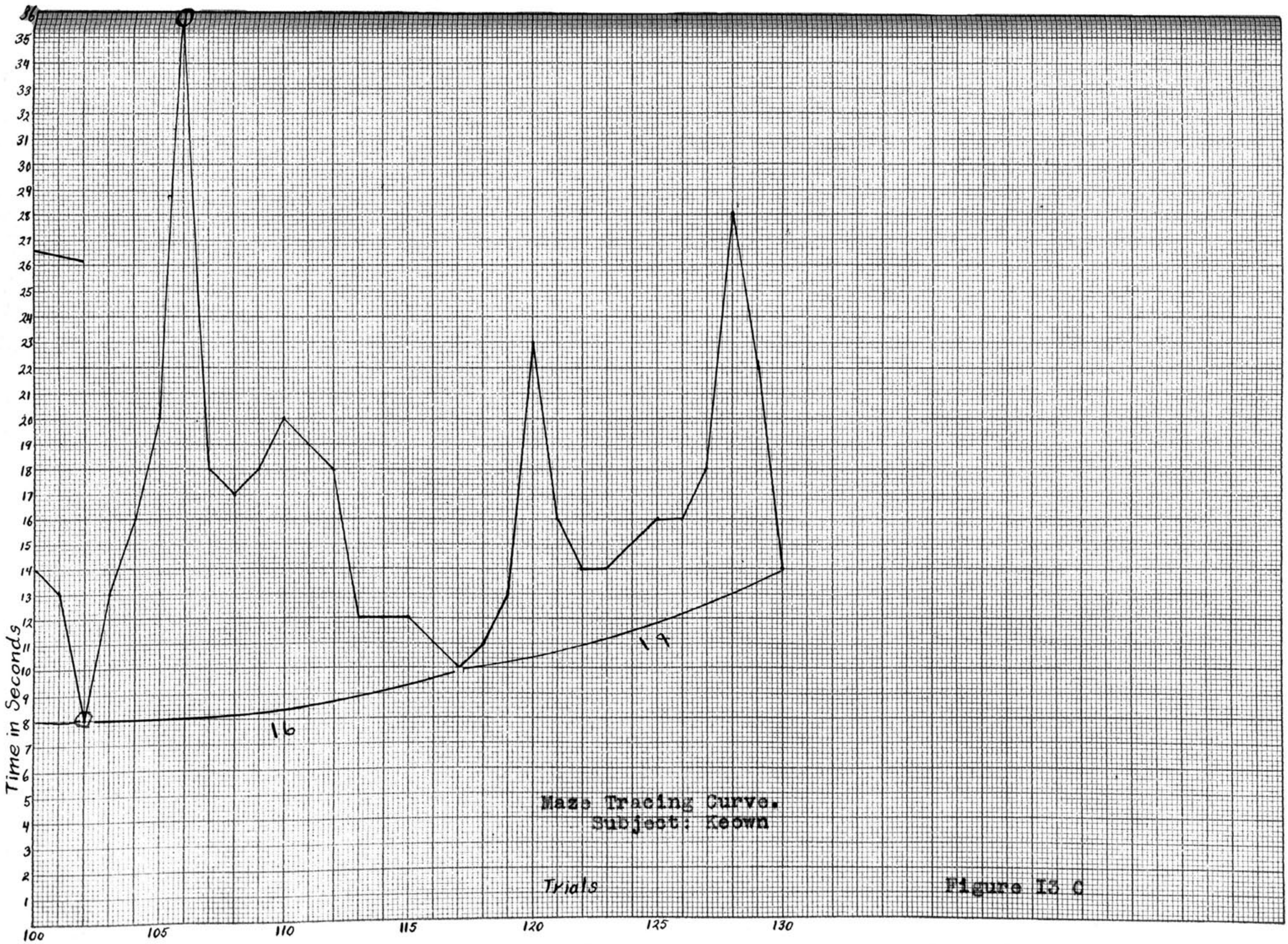
An interesting point in this curve is that the major low points and the major high points have almost the same frequency, and this frequency is almost exactly the same as the extent in trials of the major slants. The curve shows no definite minor rhythms but each major rhythm exhibits two phases. These phases differ, however, in the number of trials which they include.



Maze Tracing Curve.
Subject: Keown

Figure 13 A


Major Slant and Major Rhythm
46
31
12
Time in Seconds
Trials
Maze Tracing Curve.
Subject: Keown
Figure 15 B



Maze Tracing Curve.
Subject: Keown

Figure 13 C

All of the subjects in this part of the experiment, approximately 130, showed fairly definite rhythmic patterns. Each subject's curve revealed a pattern which was characteristic to himself alone.

The curves herein presented were chosen because they illustrated pretty clearly the various factors which we wished to point out in the technique of finding the rhythmic pattern.

Repetition of Wheeler's Study

Persistence of the Rhythmic Pattern Over a Period of Time and Extent and Nature of the Modifications of the Pattern

The subjects ran the maze once a week for three to five weeks. The curves for each week were compared to see if the rhythmic pattern had persisted and to what extent learning and practice had modified it.

The work curves of subject Morrison (Figure OMITTED) should be described for several reasons: first, because these curves are the most negative of the curves obtained in this experiment in so far as persistence of rhythmic patterns is concerned; second, because in spite of the fact that these curves are of the most negative of our results they do show some evidences of periodicity in performance; third, because these curves illustrate certain factors which we consider important in explaining some of the phenonema which influence and modify the rhythmic pattern.

This subject was a senior member of the staff of the Department of Psychology and served as a subject because of a scientific interest in the problem. She performed the experiment for a two hour period once a week over a period of four weeks. The results follow:

First week

The total number of completions of the maze pattern is 329.

The <u>major slants</u> appear to be from 1 to 90. Disregarding the first ten trials when the subject was orienting herself to the problem we get the major slants from 10 to 90 (80), 90 to 185 (95), and from 185 to 275 (90). <u>Major high points</u> appear at 87 (87), 185 (95), and 275 (90). The curve shows no <u>major low points</u>. The major rhythms appear to be from 10 to 90 (80), 90 to 177 (87), and from 177 to 272 (95). The subject shows a progressive lengthening in the extent of the rhythmic pattern.

These major rhythms appear to break up into the following minor rhythms: 40 (30), 65 (25), 90 (25), 116 (26), 145 (29), 177 (32), 211 (34), 244 (33), 272 (28), 302 (30), and 302 to X. Each major rhythm has the same number of minor rhythms, namely three. The last two minor rhythms, those of 30 and X, are probably minor rhythms of the next major rhythm.

<u>Second week</u>

The total number of completions of the maze pattern is 800. The work curve is relatively stable in amplitude and exhibits no major slants. Except at points 120 and 724 we find no points which appear to differ significantly from the standard deviation. These two points are isolated high points which rise suddenly in one trial and drop just as suddenly.

They differ from major high points which are attained gradually and from which the drop is also gradual. The curve shows no major low points. We do find in the curve certain points which though quite low show a tendency toward maxima so far as the rest of the curve is concerned. These points give us the following major rhythms: 44 (44), 120 (75), 201 (81), 271 (70), 315 (44), 393 (78), 472 (79), 538 (66), 594 (56), 654 (60), 723 (69), and 788 (65). The general pattern appears to be a short rhythm followed by three longer rhythms and then another short rhythm followed by three more long rhythms. Toward the end of the curve we find the major rhythms being broken into minor rhythms. We find that the rhythm between points 538 and 594 (56) is broken into rhythms of 34 and 22. Between points 654 and 723 (69) we find two minor rhythms, 34 and 35. Between points 723 and 788 (65) we find four minor rhythms 19, 20, 15, and 11.

Third week

The total number of completions of the maze pattern is 883. The curve exhibits no major slants, no major high points, no major low points, and the major rhythms have disappeared or at least cannot be detected by the present technique.

Certain tendencies toward a maximum are observable in sections of the curve where the subject seems to have lost the pattern which has previously kept the curve of performance at a fairly constant level. This may be related to work of Snoddy (51) who found that series practice, such as the subject was following in the present experiment, gave rise to an irradiation pattern probably caused by the simultaneous functioning of opposed musculature. Some confirmation of this hypothesis is found in that for quite some period of time in the experiment, when it is probable that the irradiation pattern has not set in, we find no tendencies toward a maximum.

The tendencies toward maxima appear in the following places on the curve: from point 305 to 325 (20), 409 to 425 (16), 597 to 607 (10), 674 to 680 (6), 735 to 754 (19), 761 to 769 (8), and 891 to 897 (6). These tendencies seemed to come at fairly regular intervals and in a definite order. We find a group of four which become progressively shorter in extent and then a group of three which also become progressively shorter.

Fourth week

The curve shows the disappearance of major slants, major high points, major low points and major rhythms. The subject seems to have attained a pattern which will give the maximum efficiency for the length of the experimental period. We find at this time large major rest periods in which the subject ran a number of trials in exactly the same length of time.

These curves show an early disappearance of the several significant points in the curve of work mentioned above and soon reach a level of performance which represents maximum efficiency. This may be due to two factors. First, this subject approached the problem with a very scientific attitude and seemed from the start to adapt an energy pattern which would permit her to complete the two hour experimental period with a minimum of fatigue and discomfort. Second, this subject was the second fastest subject of the group and far superior to the average of the group in the amount of performance. This probably is one of the factors involved in the early disappearance of the rhythmic pattern, for as Bills (8) has shown in his work on blocking, the fastest individuals have fewer and shorter blocks than the slow individuals. In the present study it appeared that the faster individuals showed fewer major high or major low points than the slow individuals and their rhythmic patterns were longer and tended to disappear sooner. This is but another way of saying that the fast individuals were less variable in their performance than the slow.

The work curves of subject Mullin (Figure 14) show very definite rhythmic patterns which persist over a considerable period of time. This subject was an undergraduate student and served as subject because of friendship for the experimenter. She traced the maze for a period of one hour once a week over a period of five weeks. The results follow:

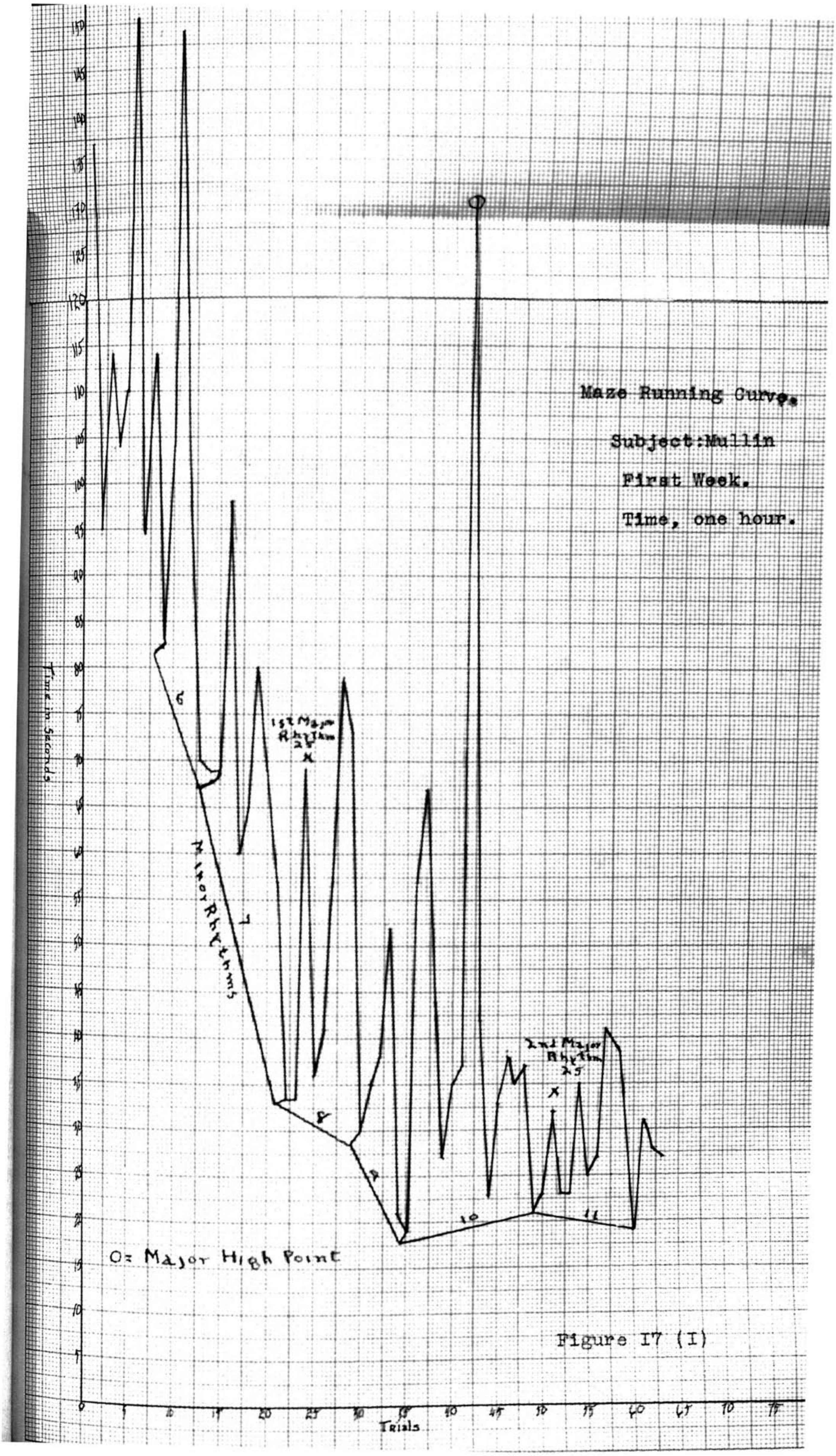
<u>First week</u>

The total number of completions of the maze pattern is 63.

<u>Major slants</u> are not noticeable in this curve. One <u>major high point</u> is noted at 43. The curve shows no <u>major low points</u> but does show throughout a general tendency toward a lower level. <u>Major rhythms</u> in this trial, as judged in terms of the tendency towards significant low points, appear to be 25 and 26. There seems to be a progressive series of <u>minor rhythms</u> in this day's work. In terms of new <u>low points</u> we find these rhythms at the following points: 9, 15 (6), 22 (7), 30 (8), 39 (9), 49 (10), and at 60 (11).

<u>Second week</u>

The total number of completions of the maze pattern is 258. No exact <u>major slants</u> are observable in this curve though there is a general tendency downward until about the middle of the curve. Two very significant <u>high points</u> appear, the first at point 130 and the second at point 251 (121),



Maze Running Curve.

Subject:Mullin

First Week.

Time, one hour.

Figure I7 (I)

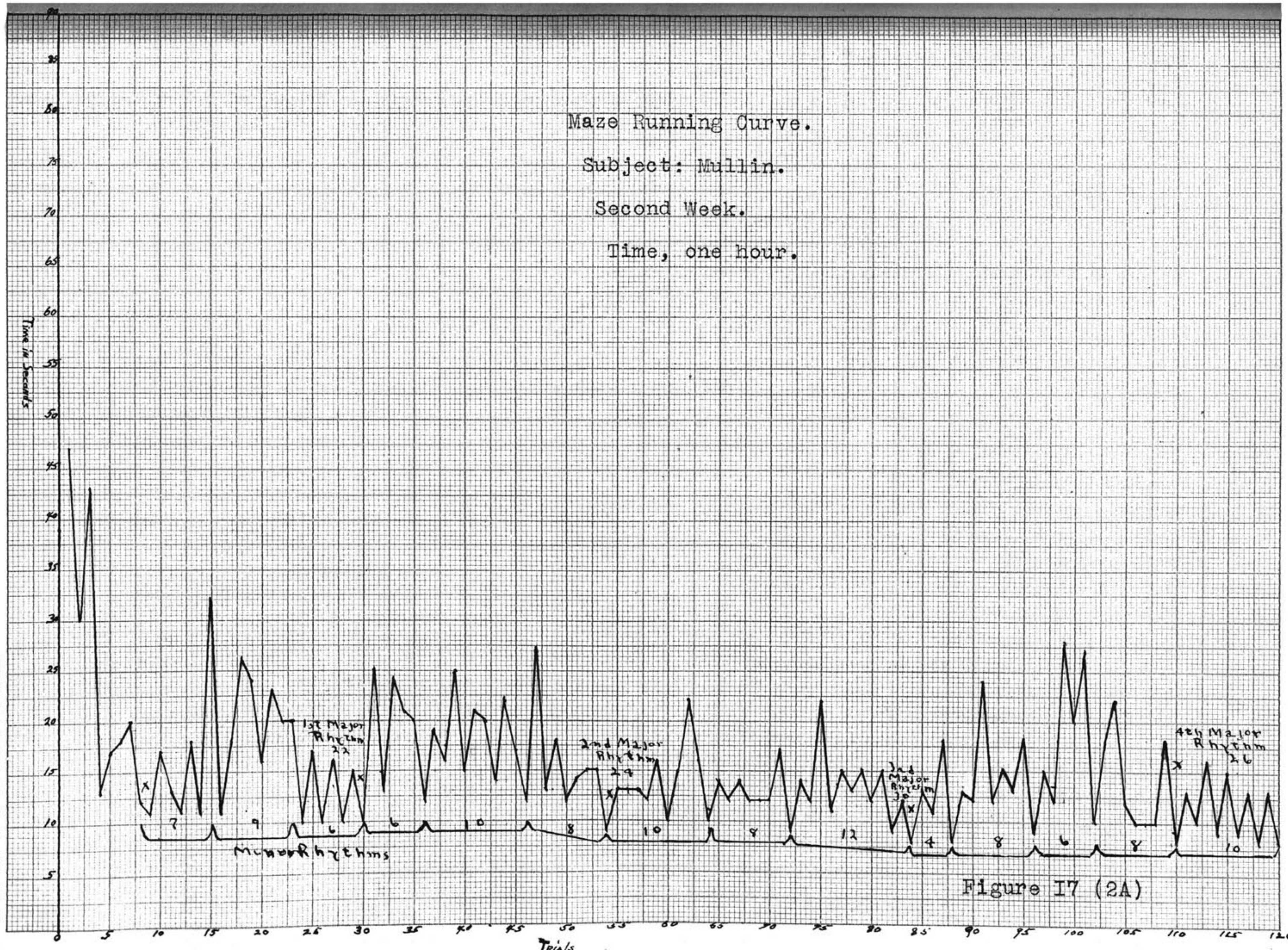

Maze Running Curve.
Subject: Mullin.
Second Week.
Time, one hour.
Time in Seconds
Trials
1st Major Rhythm 22
2nd Major Rhythm 24
3rd Major Rhythm 30
4th Major Rhythm 26
Minor Rhythms

Figure I7 (2A)

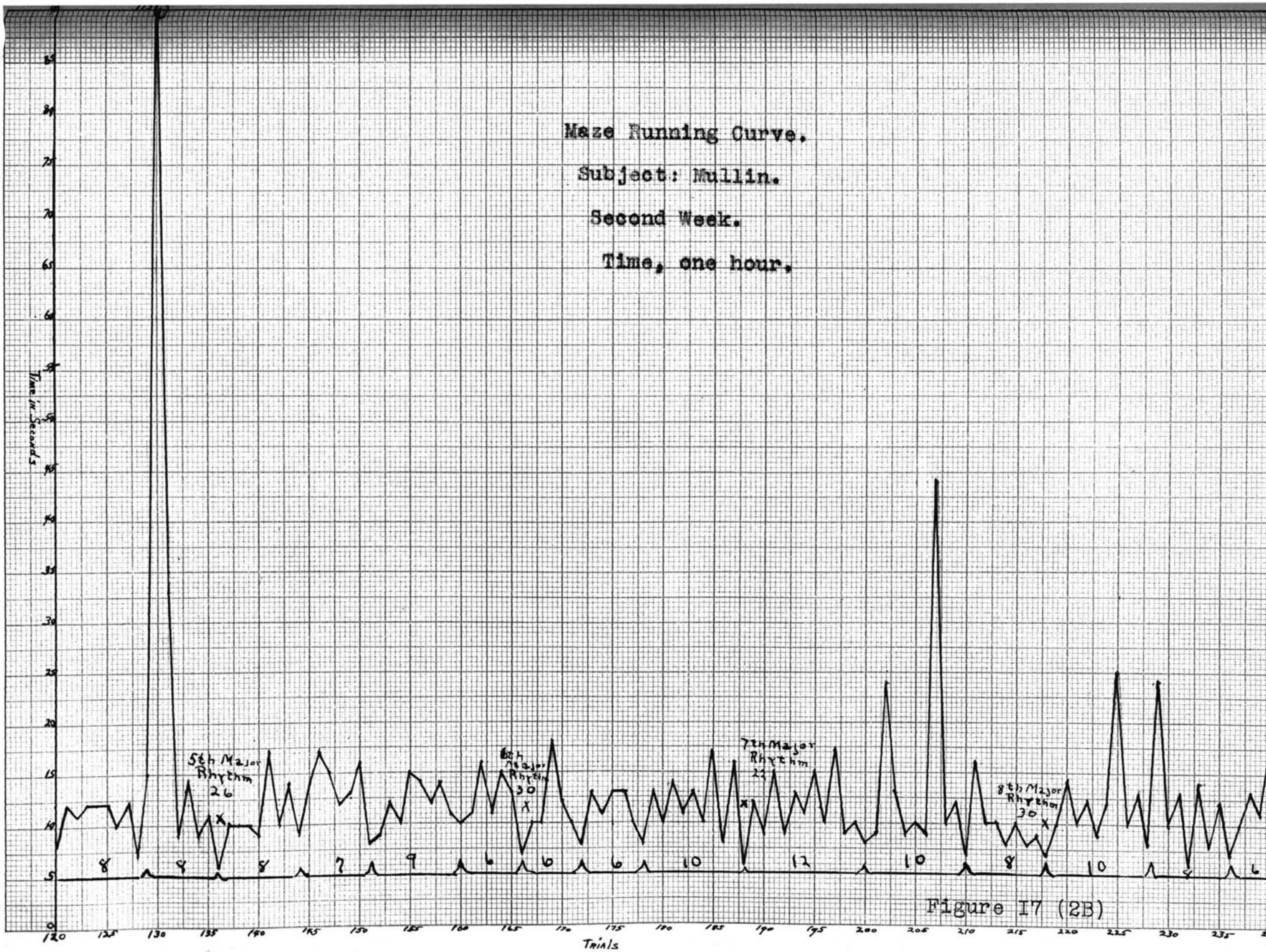
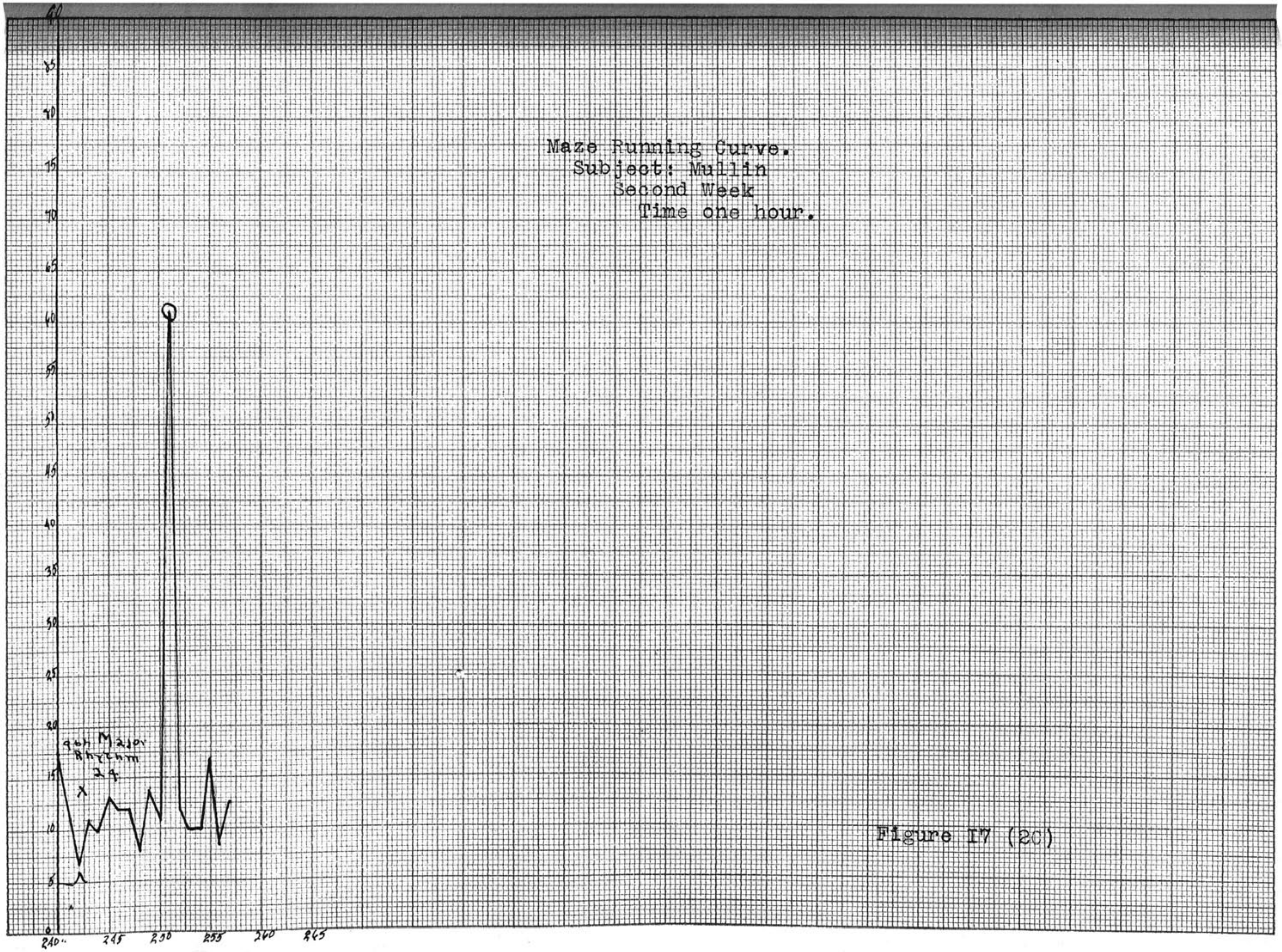
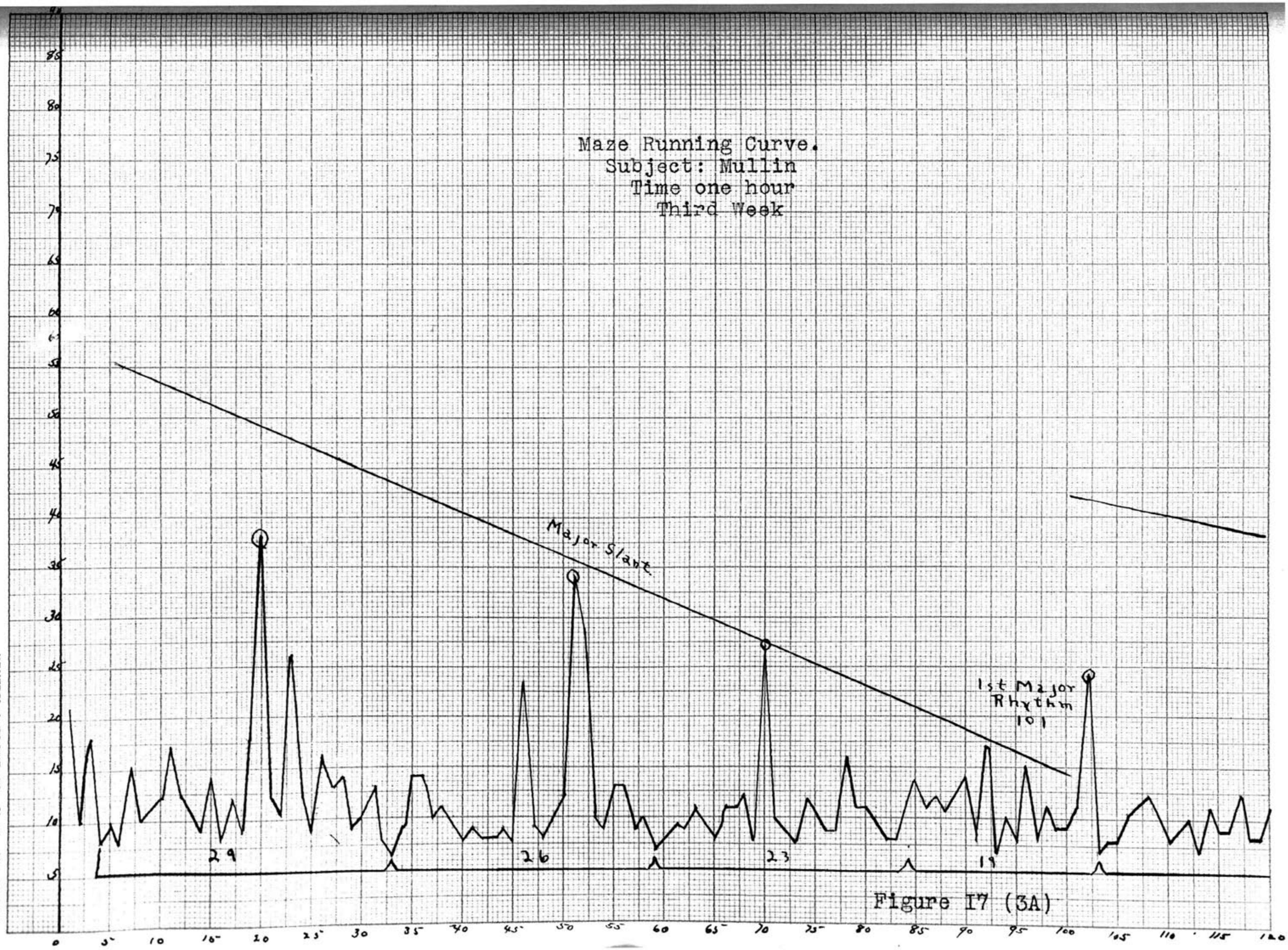

Maze Running Curve.
Subject: Mullin.
Second Week.
Time, one hour.
Time in Seconds
Trials
5th Major Rhythm 26
6th Major Rhythm 30
7th Major Rhythm 22
8th Major Rhythm 30

Figure I7 (2B)



Maze Running Curve.
Subject: Mullin
Second Week
Time one hour.

Figure I7 (20)


Maze Running Curve.
Subject: Mullin
Time one hour
Third Week
Major Slant
1st Major Rhythm
101
29
26
23
19
Figure I7 (3A)

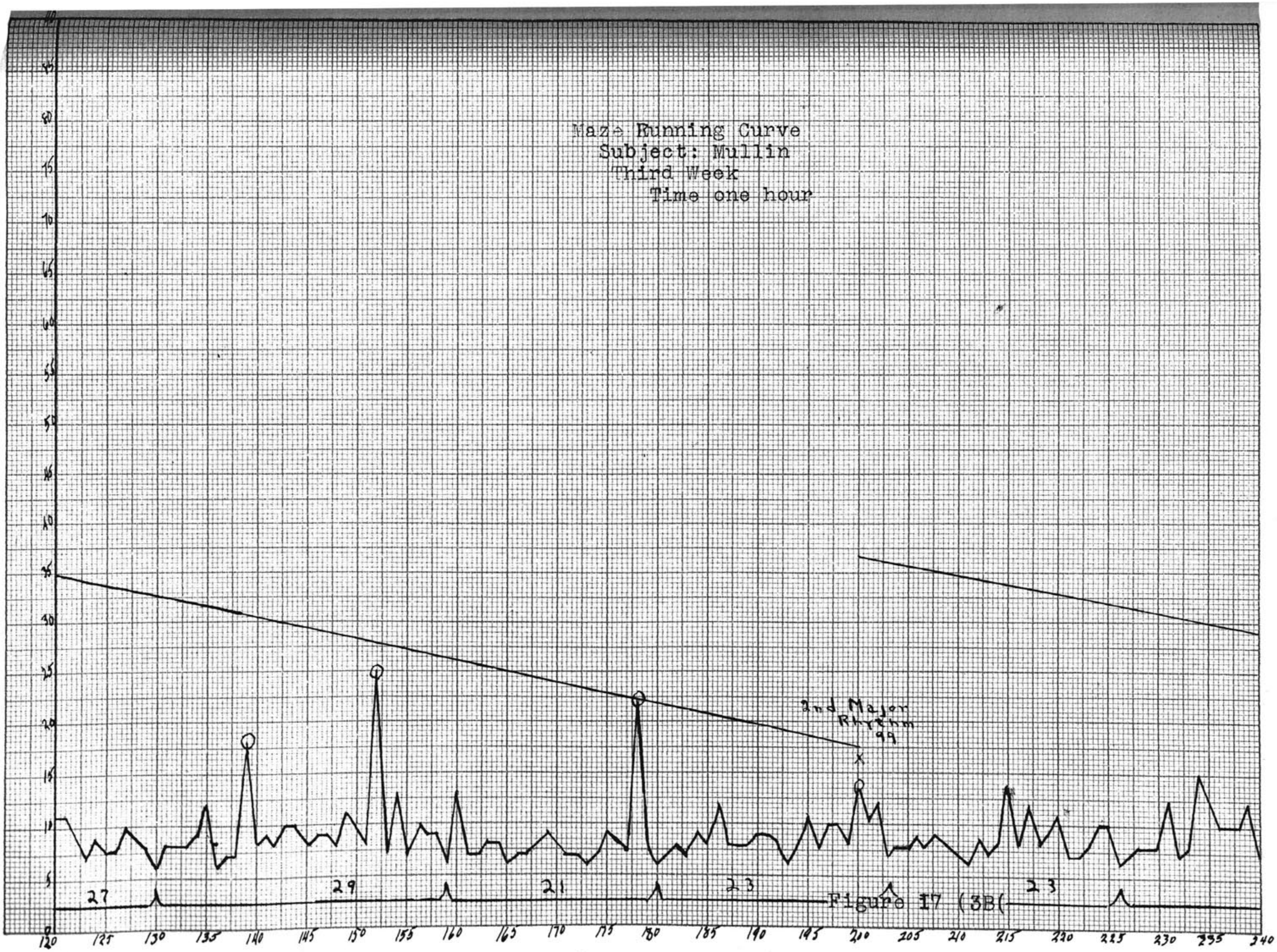

Maze Running Curve
Subject: Mullin
Third Week
Time one hour
2nd Major Rhythm 99
27
29
21
23
23
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
240

Figure 17 (3B(

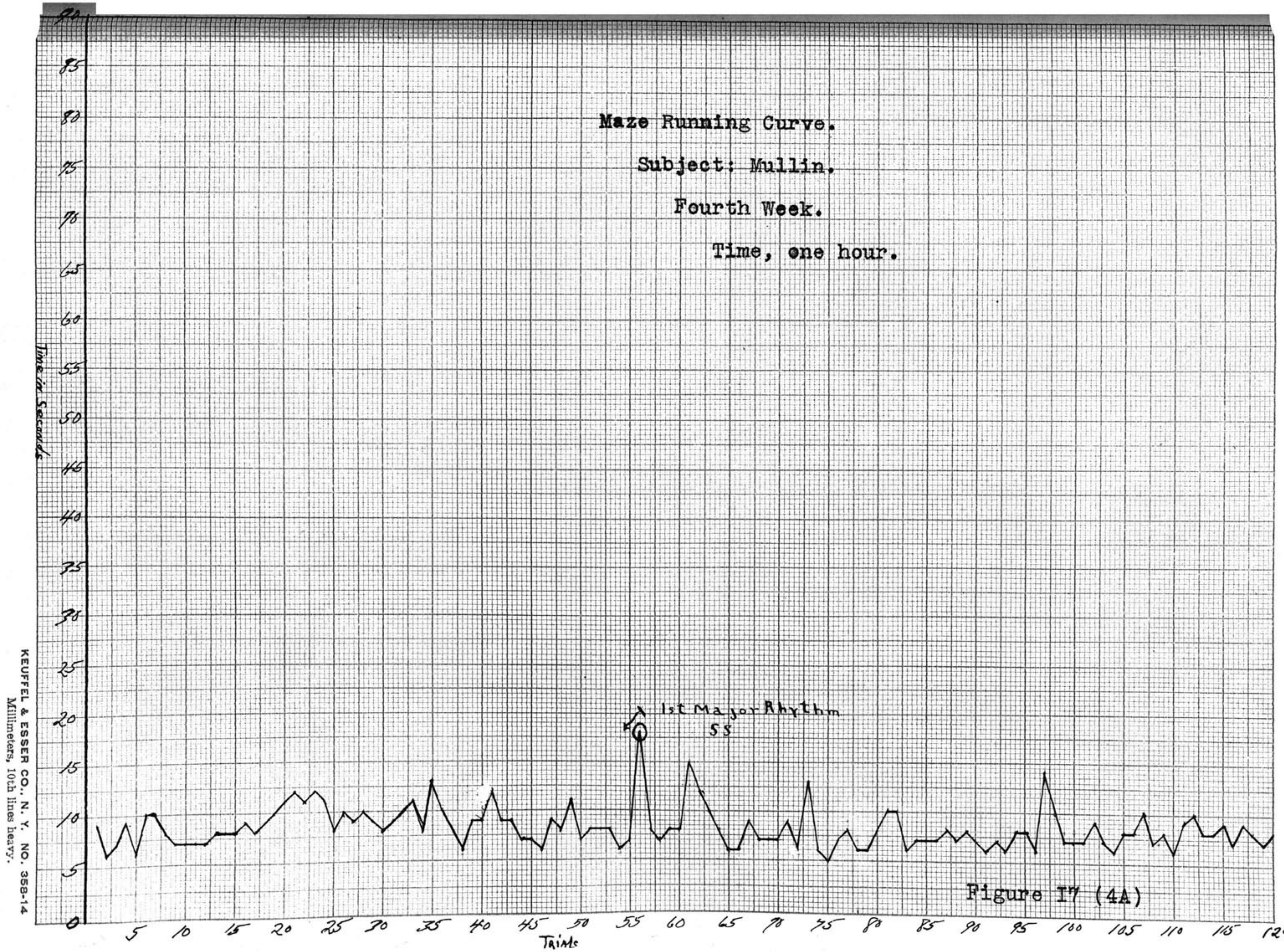

Maze Running Curve.
Subject: Mullin.
Fourth Week.
Time, one hour.
Time in Seconds
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
Trials
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
1st Major Rhythm
55
KEUFFEL & ESSER CO., N. Y. NO. 358-14
Millimeters, 10th lines heavy.

Figure 17 (4A)

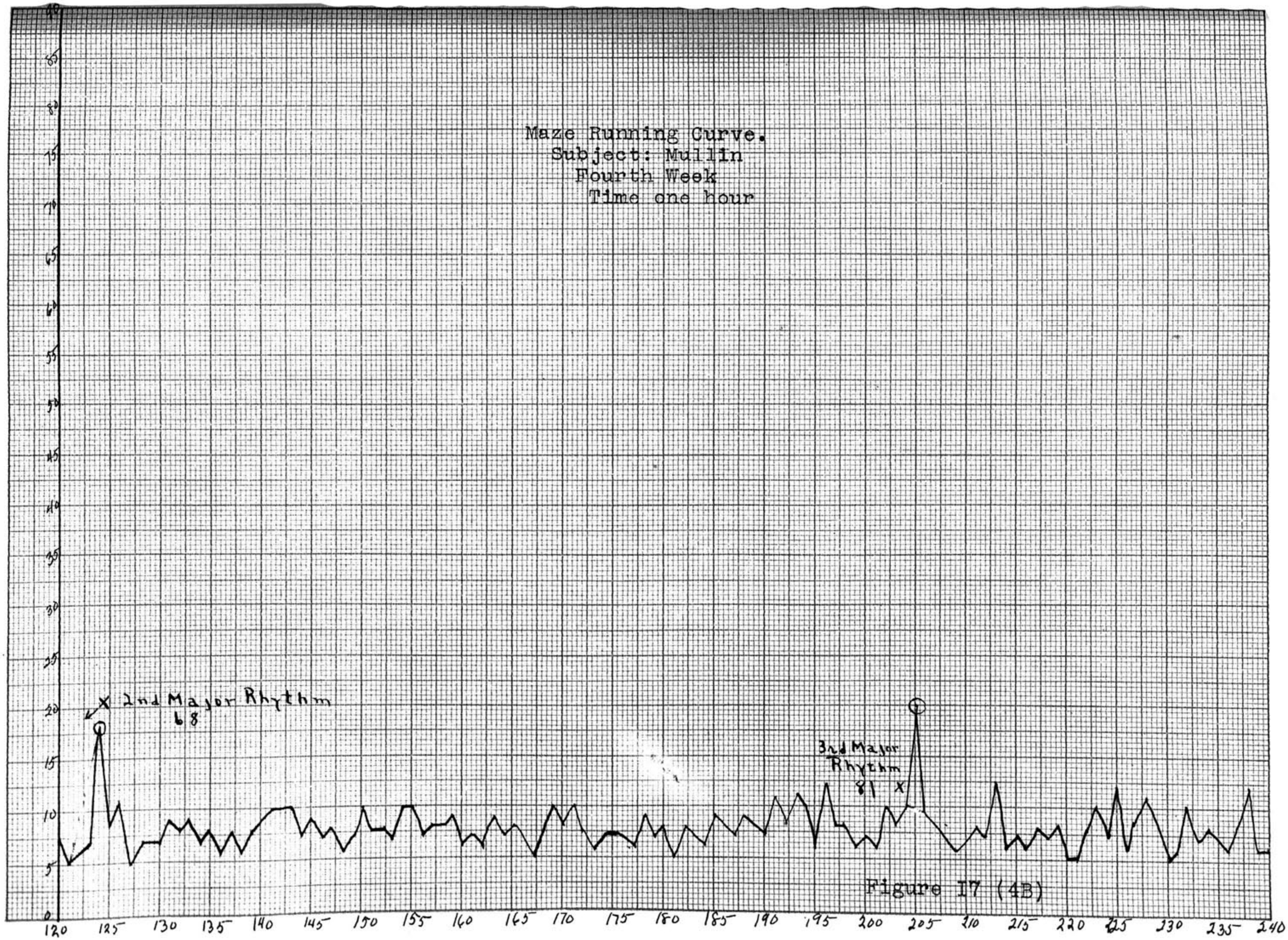
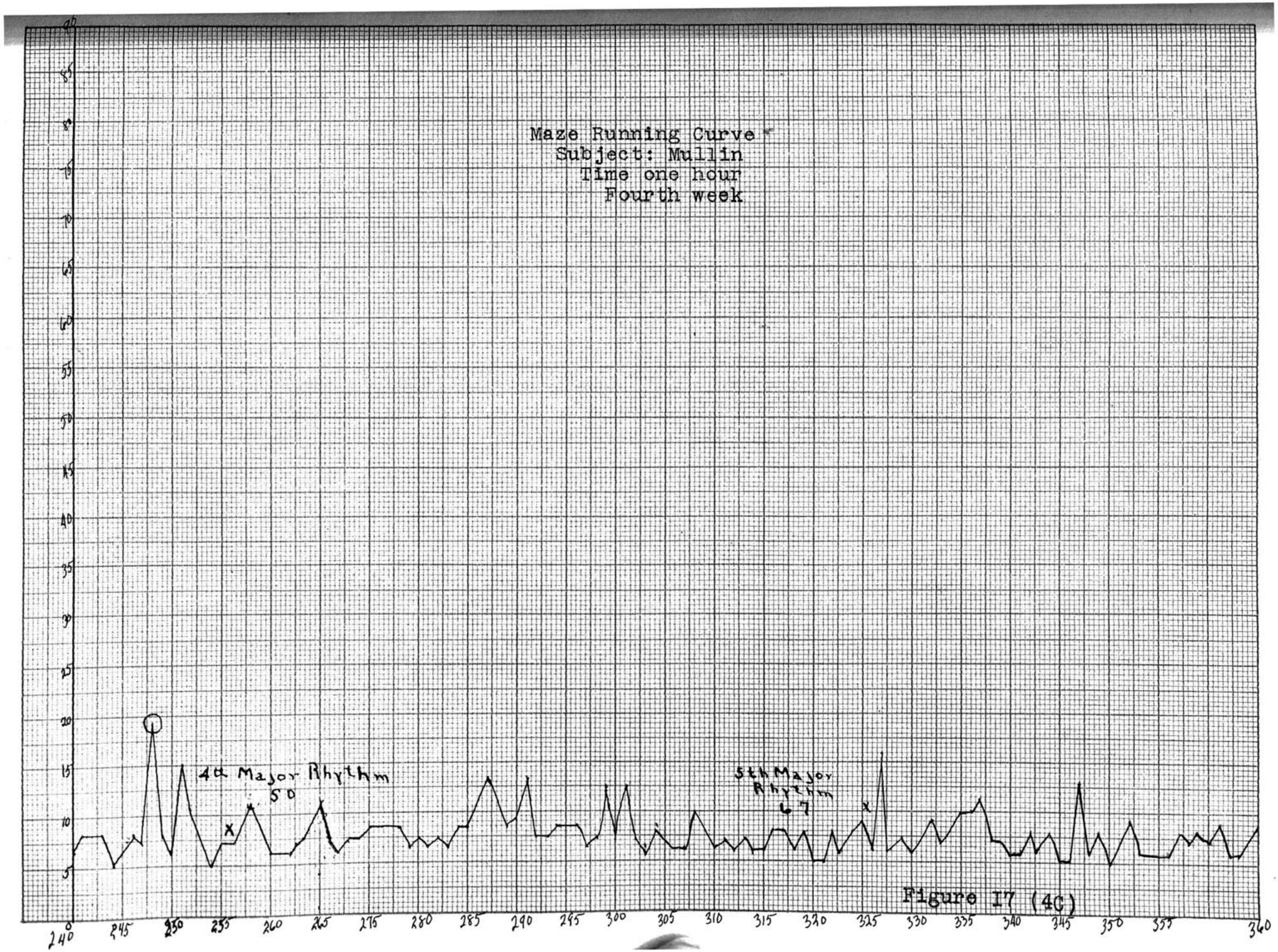

Maze Running Curve.
Subject: Mullin
Fourth Week
Time one hour
2nd Major Rhythm
68
3rd Major Rhythm
81
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
240

Figure I7 (4B)



Maze Running Curve
Subject: Mullin
Time one hour
Fourth week
4th Major Rhythm
50
5th Major
Rhythm
67
X
X

Figure 17 (4C)

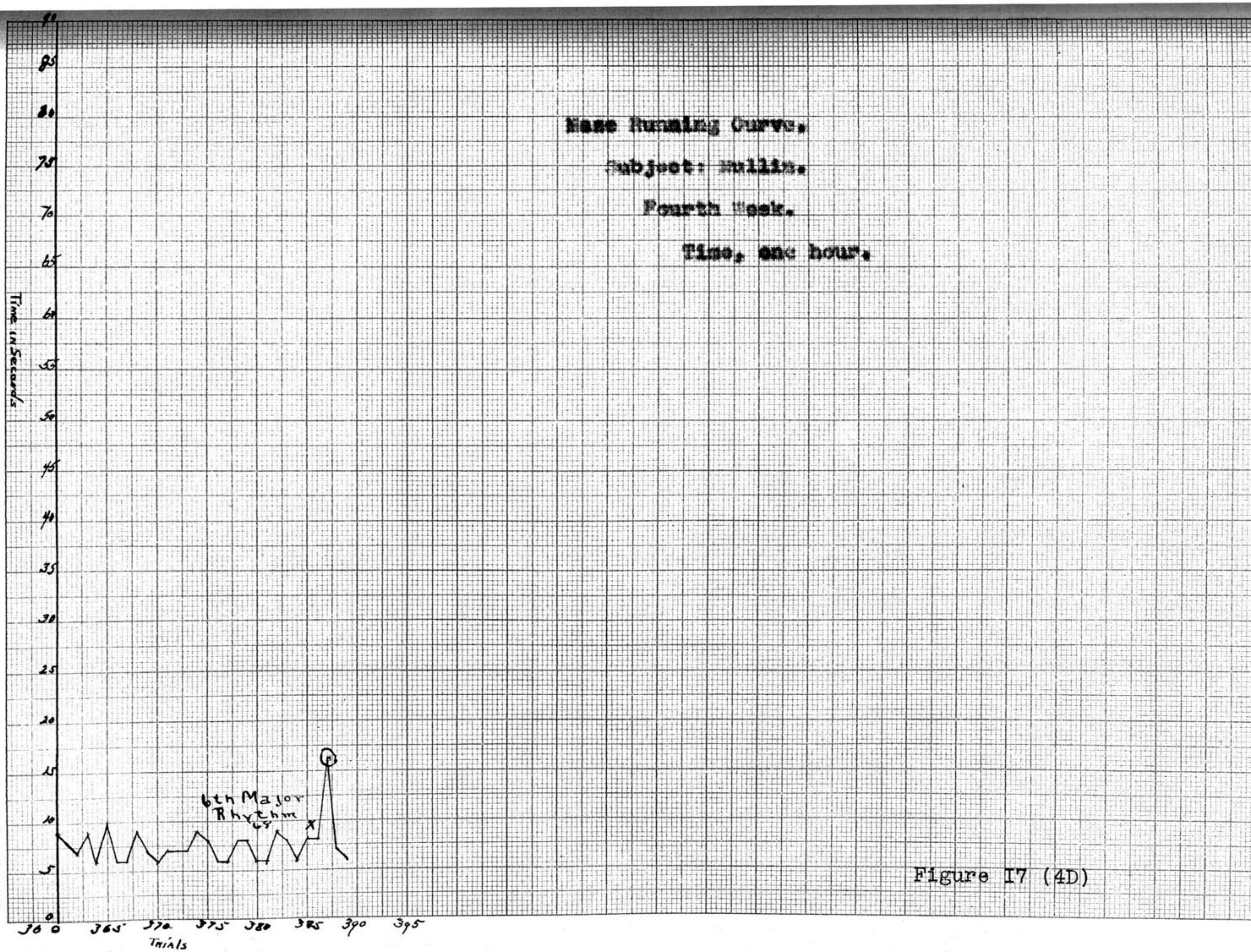


Figure I7 (4D)

KEUFFEL & ESSER CO., N. Y. NO. 358-14
Millimeters, 10th lines heavy.

which almost divide the curve in half. There are no *major low points*, but a general tendency toward a low level on the curve. There are fairly definite *major rhythms* as follows: 8 to 30 (22), 54 (24), 84 (30), 110 (26), 136 (26), 166 (30), 188 (22), 218 (30), 242 (24). These major rhythms exhibit smaller rhythmic patterns within themselves as follows: 22 (7, 9, and 6), 24 (6, 10, and 8), 30 (10, 8, and 12), 26 (4, 8, 6, and 8), 26 (10, 8, and 8), 30 (8, 7, 9, and 6), 22 (6, 6, and 10), 30 (12, 10, and 8) and 24 (10, 8, and 6).

Third week.

The total number of completions of the maze pattern is 345. This curve shows very definite *major slants*: the first is from 1 to 101 (101), the second from 101 to 200 (99), the third from 200 to 301 (101). The *major high points* are not so significant in this curve. They keep decreasing in size in accordance with their position in the major slant and their appearance is not as regular as in the preceding trials. They occur at the following points: 20 (20), 51 (31), 70 (19), 103 (33), 140 (37), 152 (12), 178 (26), 200 (22), 248 (48), 282 (34), 305 (23), 320 (15), and 340 (20). There are no especially significant *major low points* in this curve. The *major rhythms* are the same as the major slants, that is 101, 99, and 101. Certain definite minor rhythms appear in this curve at the following points: 4 to 33 (29), 59 (26), 84 (23), 103 (19), 130 (27), 159 (29), 180 (21), 203 (23), 226 (23), 250 (24), 272 (22), 298 (26), and 327 (29). These minor rhythms are divided into the following number of phases: 3, 2, 2, 2, 3, 3, 3, 2, 3, 3, 3, 3, 3, and 2.

The curve for the fourth week shows no major slants. The major high points, while not particularly great in amplitude, do tend to mark the curve off rather sharply. They occur at the following points: 56 (56), 124 (68), 205 (81), 258 (53), 322 (64), and 387 (65). No major low points appear. The major rhythms are as follows: from 1 to 55 (55), 55 to 123 (68), 123 to 204 (81), 204 to 254 (50), 254 to 321 (67), and from 321 to 389 (68).

The work curve for the fifth week shows a further modification in the rhythmic pattern. The total number of completions of the maze pattern by the subject in this particular curve was 463. No major slants are apparent in the curve of work. With the exception of trials 213 to 235 the curve shows no significant major high points. These trials, however, are quite important for they clearly indicate a loss of the pattern on the part of the subject. This loss of pattern which indicates the onset of an irradiation pattern seems to divide the total number of completions almost in half. The <u>major rhythms</u> appear to be from 1 to 59 (59), 59 to 126 (67), 126 to 210 (84). Here the subject shows the loss of the pattern. The next major rhythm is from 235 to 320 (85), and finally from 320 to 400 (80). The work did not extend long enough for us to get the next major rhythm after the four hundredth trial. This curve marks the first appearance of the <u>major rest periods</u>.

The curves for the subjects who traced the maze for half an hour exhibit, on the first day, rhythms about the same as the one and two hour subjects, though the pattern is considerably lower in amplitude and longer in extent. On the succeeding days the curves showed an absence of major high points, major slants and major low points. The subjects seemed to strike their level of maximum efficiency almost immediately as is shown by the early appearanse of major rest periods.

All, with the possible exception of the half hour subjects, showed evidence of the existence of rhythms in their work curves. These rhythms persisted over a considerable period of time. The general level of the curve may fall, but the form remains relatively constant. With the passing of time the major high points dropped; the major rhythms spread out as though the curve had been flattened. The major low points tended to disappear as the learning increased.

As the learning process continued, <u>major rest periods</u> began to appear. These may be periods in which the state of muscle coördination and nervous impulses are best balanced. These rest periods continued to grow larger until the rhythms seemed to disappear and the time curve became a relatively straight line.

Initial-spurts, End-spurts, and Warming-up Periods

The work curves from this experiment present no evidence of the existence of 'initial' or 'end-spurts', or of a 'warming-up' period, despite the fact that the subjects were told the time every minute for the first fifteen and the last ten minutes of the experiment and at ten minute periods throughout the course of the experiment. Instead in many cases we find a decided rise in the time curve for the last ten minutes. This agrees with the findings of Reed (41) who showed that in a 10 hour period of continuous addition there was no evidence of 'initial-spurt', 'end-spurt', or 'warming-up' period, even when time was called every minute for the first fifteen and the last ten minutes of the experiment, and at the end of every ten minute period.

These findings also agree with the work of Robinson and Heron (44) who found that the warming-up effect seemed absent where the work was continuous, for the fatigue effect is maximally favored and the warming-up effect is concealed. (In the light of the present paper the curves shown in the work of Robinson and Heron showed evidences of a characteristic rhythm though the length of the experiment was hardly long enough to show more than one or two major phases of the rhythm.)

The present study indicates that a drop in the work curve either at the beginning or the end depends on whether the subject is in one of the high phases or in one of the low phases of his rhythm at the time.

Relation of Increasing Efficiency to Accuracy
of the Visual Image of the Maze

The experimental results of the present study indicate that there is no relation between increasing efficiency in tracing the maze and accuracy of the visual image of the maze as shown by the drawings. Of the ten subjects that reproduced the maze pattern there was only one whose drawings resembled that pattern; the rest had some vague ideas of the path but in their drawings left out many of the parts and also added parts which were not present in the pattern. All the subjects became less accurate in their drawings as the experimant progressed. (The same subject whose drawings were the only ones that resembled the pattern of the maze very closely also showed improvement in her drawings throughout the course of the experiment. We believe that this subject had se n the maze, either through her goggles which may not have fitted very tight or on one occasion when the experimenter left the roon.

The introspective reports of the subjects seem to show that they did not have a very good visual image of the maze pattern. Some of the introspective reports follow:

Subject: Mullin.

First Week. Thinks that the experimenter is changing the position of the maze, that she should have reached the goal and is surprised when she finds that she isn't there.

Second Week. Maze pattern seems different from the pattern of the first week. Does not know when she has reached the goal. Everything seems different.

Third Week. Everything seems wrong in the pattern. Could not remember the maze pattern.

Fourth Week. Wonders where the end is.

Fifth Week. Seems unfamiliar with the maze. Maze seemed unconnected. Can't find self. Reports a loss of the pattern.

Subject: Ganson

First Week. Thinks that the pattern changes from time to time.

Third Week. Everything seems changed.

Subject: Morrison

Second Week. Thinks that the maze changes from time to time. Reports a loss of pattern of previous week.

A study of the relationship between increased efficiency in maze tracing and accuracy in the drawings of the maze disclosed two important points which substantiate the work of Wulf (59) who found that if subjects were shown a series of objects for a short time and later asked to draw them, their drawings would show significant variations from the original objects. The variation was either in the nature of a "sharpening" or a "leveling", and it became more pronounced the longer the time between the exposure and the drawing. Examination of the series of drawings of the same object showed that the direction of the modification was indicated in the very first drawing. Whether the modification occurred in the direction of sharpening or leveling depended on the conditions existing in the observer. The reproductions tended to become more symmetrical over a period of time.

Perkins (38) in a study of symmetry in visual recall, in which he followed in general the same technique as Wulf, found that the voluntary reproductions of visually perceived forms undergoes a change towards symmetry and simplification. A change toward simplification of a given figure may assume two forms. First, there are omissions of parts of the original stimulus-figure. In most cases the omission is of some part which stands alone in the figure and upsets the balance of the figure. The second form is decrease in size of some characteristic of the original figure. Thus, if a particular figure has a line which upsets the balance of the figure, that line may be shortened in successive reproductions.

The following drawings and descriptions show the development of the memory image of the maze pattern over the period of the experiment.

Subject: Mullin

First Week. Maze pattern seemed quite large and had many large convolutions. Subject reports that the maze has blind alleys but the drawings do not show any blind alleys. No difficult parts of the maze are reported, but the first, middle and last parts are reported as being the easiest.

Second Week. Maze pattern is considerably smaller than the first week's drawing. Convolutions are fewer and smoother. Same reports as to easy and difficult portions of the maze.

Third Week. Maze pattern about the same size as it was the second week. Still less convolutions shown in the drawing and the ones which remain are smoother. This smoothing effect is especially noticeable in the first and middle parts of the maze where actually the pattern is the most complicated. Subject reports the first part of the maze as easy but not the middle part as it has been reported the first two weeks. The last part of the maze is now reported as being difficult.

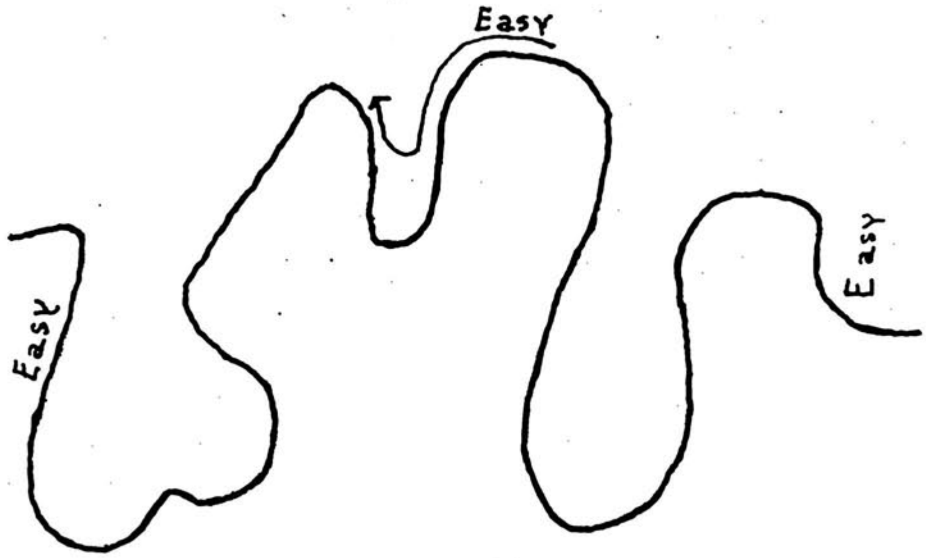
Fourth Week. Maze pattern is considerably diminished in amplitude and slightly decreased in size. Same number of convolutions is shown in the drawing with still further smoothing being evident. Same report as on the third week as to the difficult and the hard parts of the maze.

Fifth Week. Maze pattern slightly larger than the fourth week's drawing and about the same size as the drawings made on the second and third weeks. Same number of convolutions is shown with a still further smoothing of the curves. The drawing is the most simplified of the series. No easy parts are reported in the maze. The first and last parts are reported as being difficult.

Drawings of the Maze Pattern

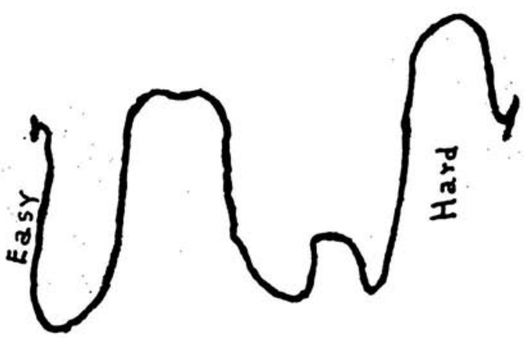
Subject: Mullin

First Week



Second Week

Third Week

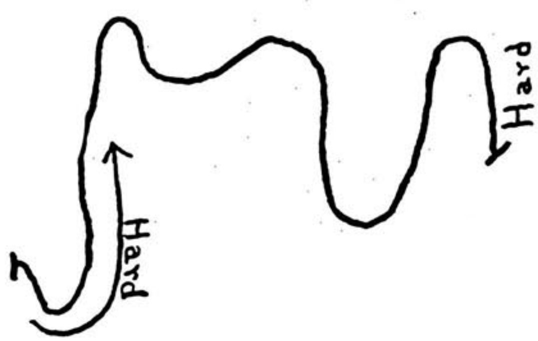


Drawings of the Maze Pattern

Subject: Mullin

Fourth Week

Fifth Week



Subject: Ganson

First Week. Subject reports no blind alleys but thinks that the position of the maze is changed from time to time. Maze pattern is very convoluted. First part of the maze is reported as being difficult; last part reported as being the easiest.

Second Week. Maze pattern has about the same length but the amplitude is considerably higher than that of the first week. Smoothing is quite noticeable especially in the middle part of the pattern. Pattern is much simpler than that of the first week. The middle part is now reported as the difficult part and the last part is still reported as the easiest part.

Third Week. Maze pattern much shorter in length than that drawn the second week. Convolutions are much diminished in size and are fewer in number. Amplitude is much less than the second week. Pattern is very simple. No part of the pattern is reported as being difficult. The last part is reported as being easy.

Fourth Week. Maze pattern still further diminished in size, reduced in amplitude, convolutions fewer and much smoother. The drawing represents a very simple, rather symmetrical figure. No report as to any difficult part. The last part is still reported as being the easiest.

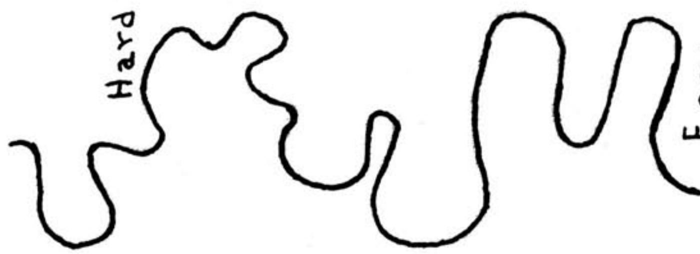
First Trial, Second Year. This drawing was made after the subject's fifth trial in tracing the maze pattern, and was six months after the fourth trial. Size of the maze pattern is somewhat larger than that of the fourth week. Same number of convolutions is shown but they are very smooth and regular. Amplitude is higher than that of the fourth drawing. Middle part reported as being difficult; last part reported as being the easiest.

Second Trial, Second Year. One week after the first trial the second year. Maze pattern the same in size and amplitude as that of the first week the second year. Convolutions fewer and smoother than the week before. Pattern is very simple and quite symmetrical. No part of the maze is reported as being difficult. The last part is reported as being easy.

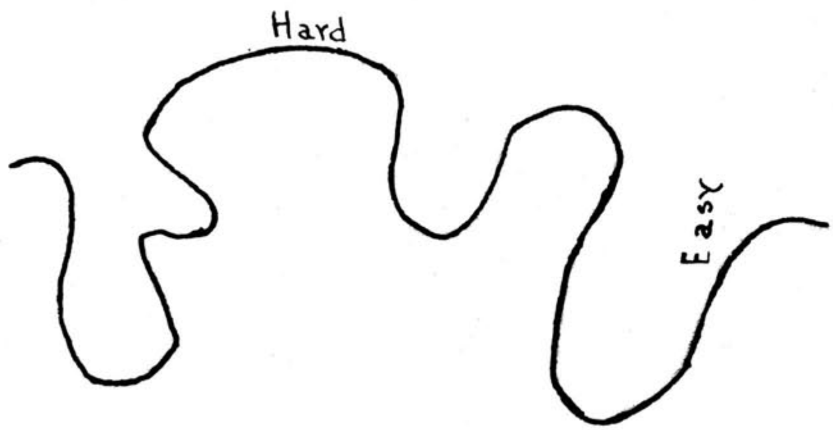
Drawings of the Maze Pattern

Subject: Ganson

First Week



Second Week



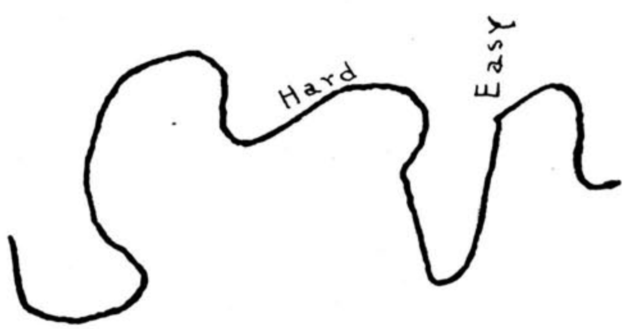
Third Week

Drawings of the Maze Pattern

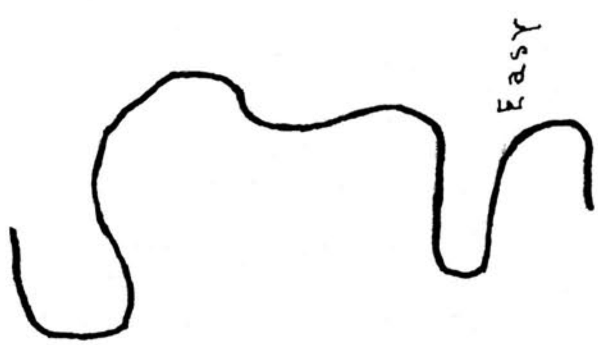
Subject: Ganson

Fourth Week

First Trial Second Year (six months later)



Second Trial Second Year



Subject: Morrison

First Week. This subject reported blind alleys in the maze pattern as are shown in the drawings. Pattern is very complex and possesses blind alleys at the first part and also towards the end of the maze. Subject reports the zig-zag part of the maze as being hard and reports the middle portion as being the easiest.

Second Week. Pattern slightly larger in extent and slightly lower in amplitude. The blind alley at the first part has straightened out though it remains practically the same size. The zig-zag portion has smoothed out considerably as has also the circular part in the middle. The last part of the maze including the blind alley is quite a bit larger in extent and shows the addition of a blind alley after the end of the maze. The part of the pattern which follows immediately after the circular part in the center shows the smoothing effect. The subject reports no part having any great difficulty and again reports the middle part as being the easiest.

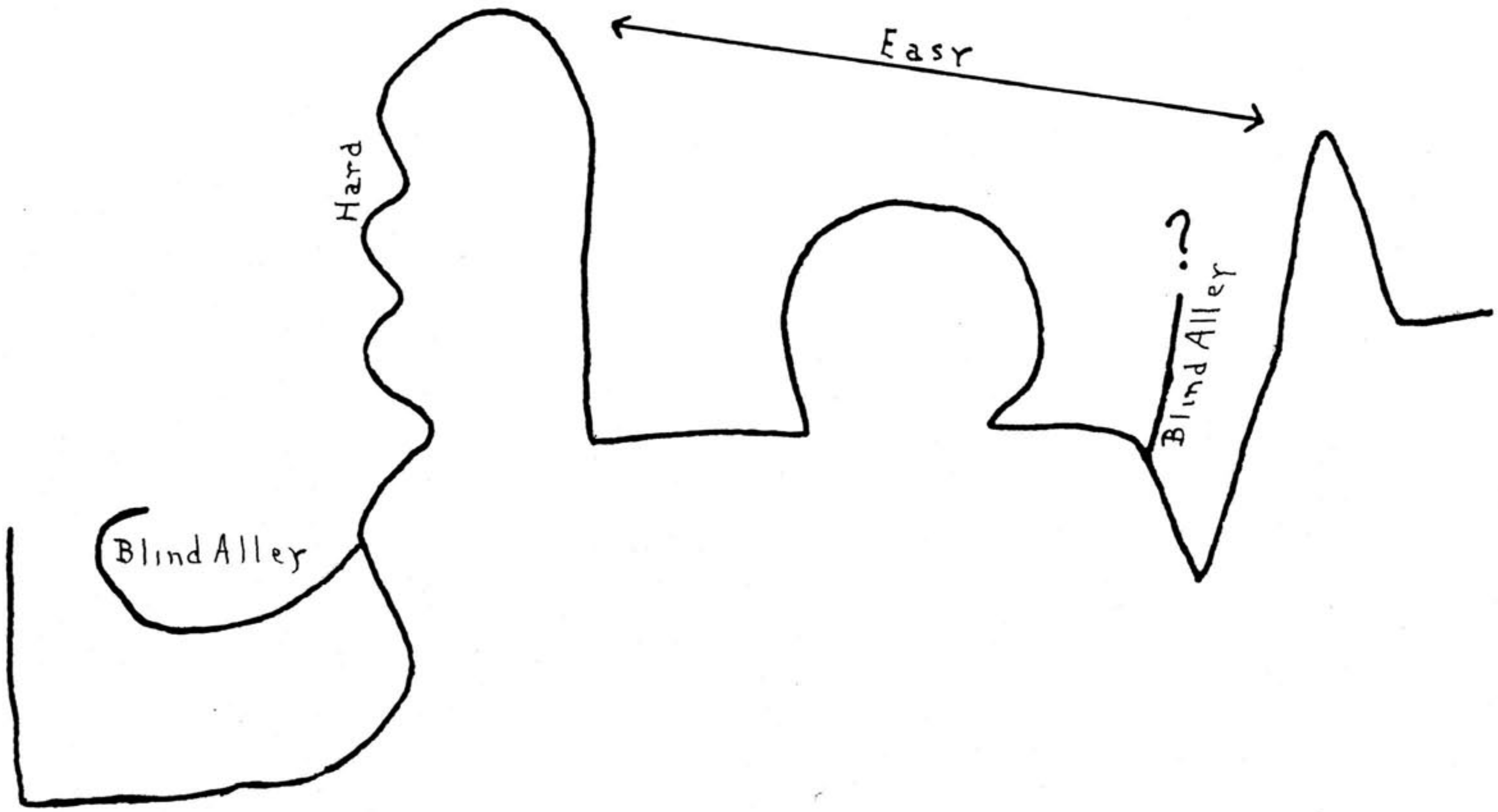
Third Week. Pattern about the same in extent as the second drawing, but lower in amplitude. The blind alley at the beginning has shortened still further and the zig-zag part has become longer and smoother. The blind alley at the end has become a curved ending. The middle portion of pattern is still reported as being the easiest.

Fourth Week. Pattern is smaller in extent and also lower in amplitude. The blind alley at the beginning of the maze has become modified until it persists as a mere projection. The zig-zag part of the maze is considerably shortened. The blind alley near the end has also shortened. The end of the pattern has assumed its true position. The middle portion is still reported as being the easiest.

Drawings of the Maze Pattern

Subject: Morrison

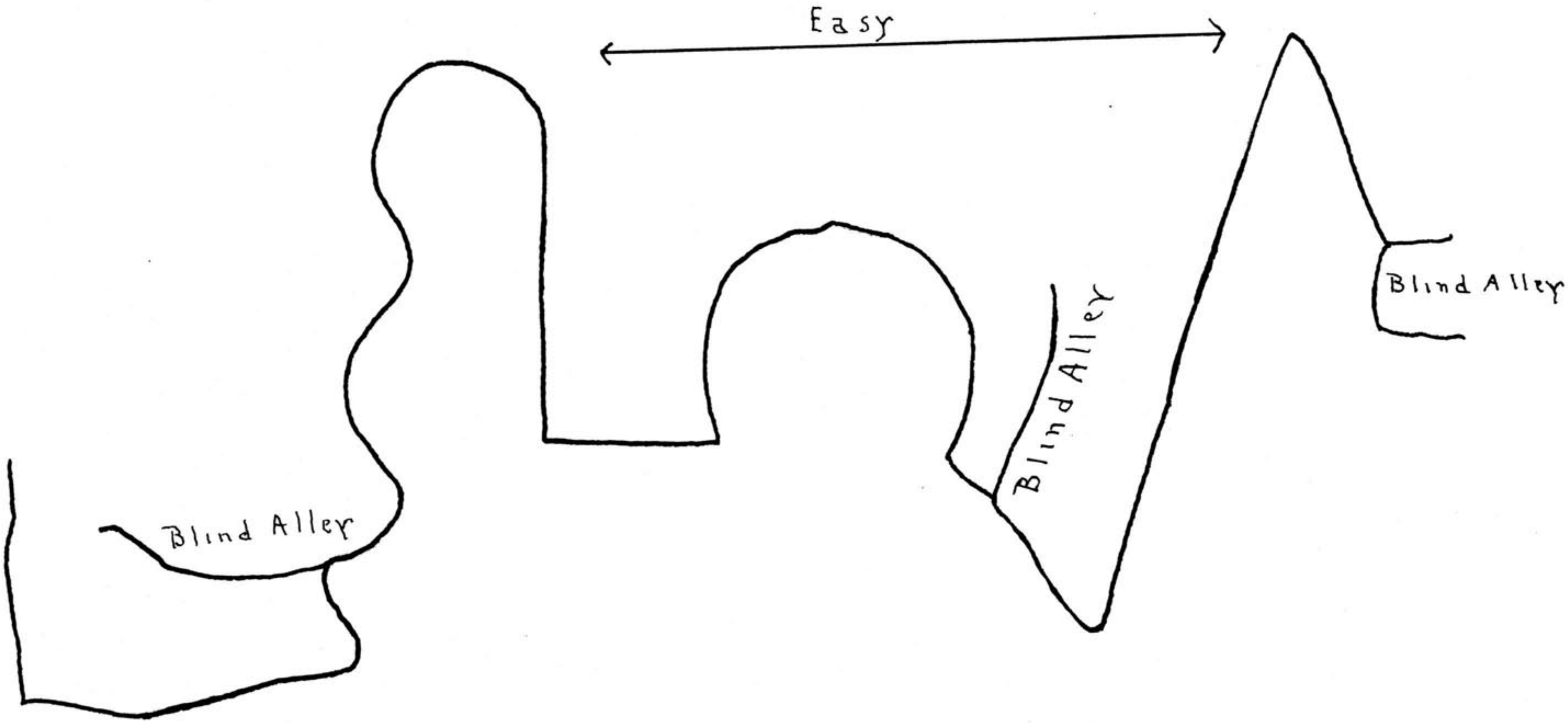
First Week



Drawings of the Maze Pattern

Subject: Morrison

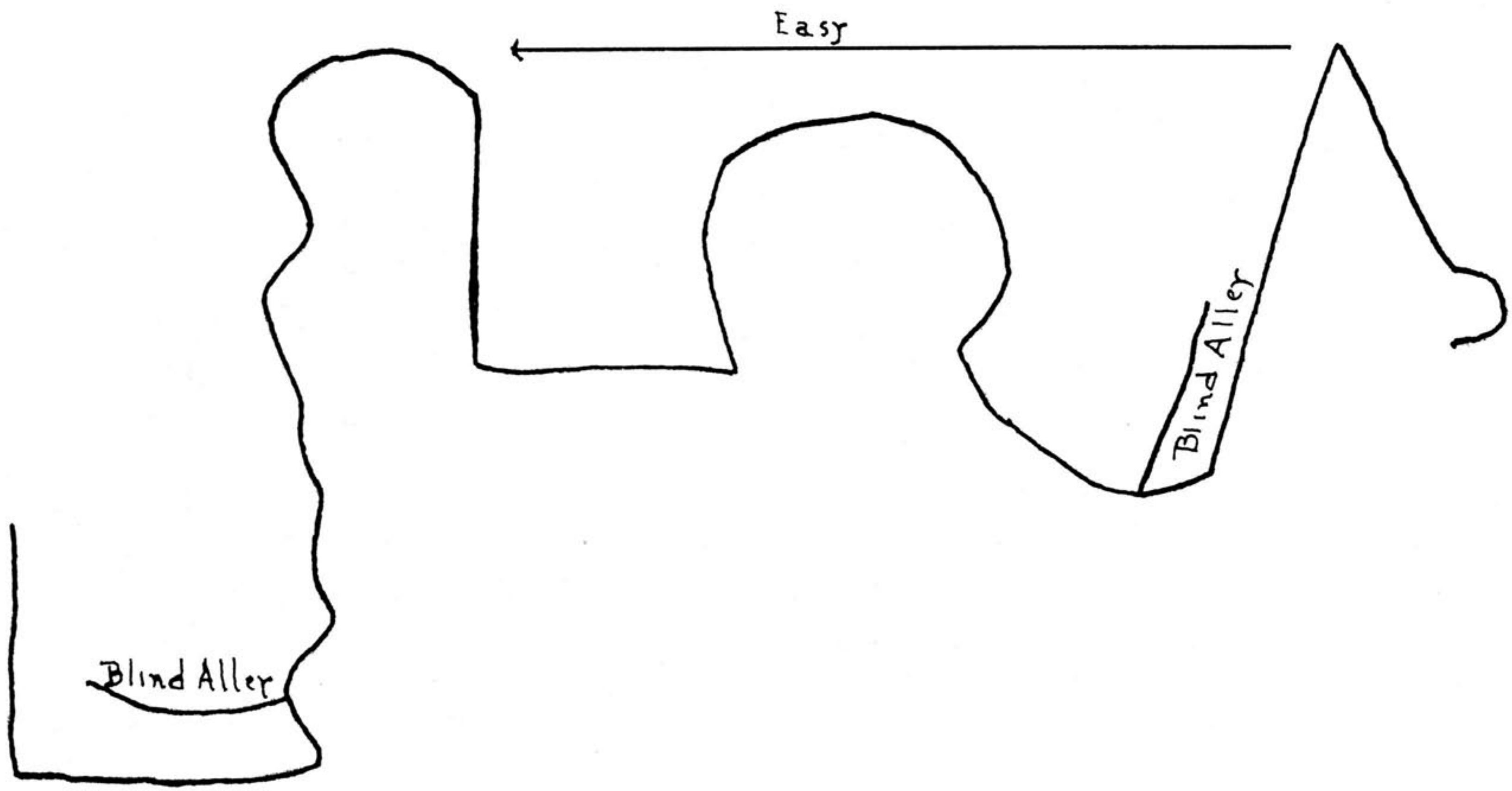
Second Week



Drawings of the Maze Pattern

Subject: Morrison

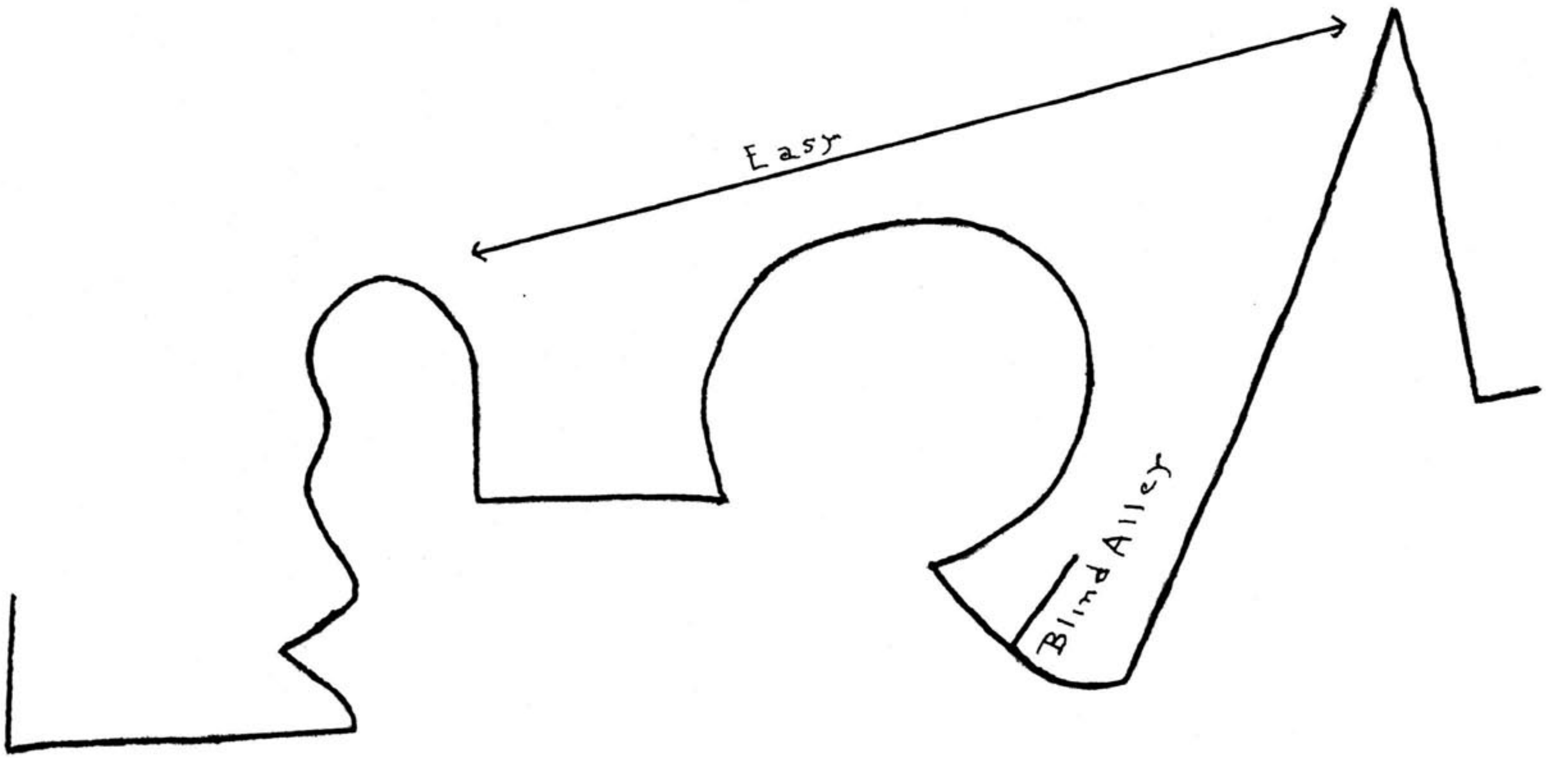
Third Week



Drawings of the Maze Pattern

Subject: Morrison

Fourth Week



These experimental results show that the memory-image of a pattern which is not observed visually undergoes the same modification over a period of time as does the recall of a visually observed figure.

Subject: Mullin shows in her drawings of the maze pattern (Drawings 1 to 5) a progressive tendency towards leveling, the amplitude and extent of the pattern show a progressive reduction. The convolutions which are really the hard parts of the maze, the parts which stand out alone, and throw the rest of the figure out of balance are smoothed out and made more symmetrical. The pattern becomes progressively more simple.

Subject: Ganson shows in her drawings of the maze pattern (Drawings 1 to 5) a progressive tendency towards leveling, the amplitude and extent of the pattern show a progressive reduction. The convolutions show a progressive smoothing effect. The pattern becomes progressively simpler.

Subject: Morrison shows in her drawings of the maze pattern a tendency towards leveling only in the decrease in the amplitude of the pattern. She shows a progressive tendency towards simplification, in agreement with the findings of Perkins (38) that simplification may occur by the decrease in size of some line which tends to upset the balance of the figure. In her drawings (Drawings 1 to 5) she shows at first certain blind alleys which are not in the maze. These straighten out and become shorter so that one of them becomes a mere projection in the first part of the maze.

All the subjects except one showed leveling, tendency toward symmetry and a tendency toward simplification.

A possible explanation for this leveling and simplification process appears to be in the conditions existing in the observer. As the experiment goes on the subject progresses in efficiency and runs the maze much faster than at first; hence this increased speed is interpreted as a shortening and leveling of the maze pattern. Also, since the subjects do not lose so much time in the zig-zag and the circular sections this is interpreted as a smoothing out of the obstacle in the drawings. Some verification of this explanation is found in the fact that as the smoothing out in the hard spots begins to appear in the drawings the subjects no longer report them as being the difficult portions of the maze pattern.

The Relation Between the Length of the Experimental Period and the Length and Amplitude of the Rhythmic Pattern

From a comparison of the work curves of the two, one, and half hour subjects, it is very clear that there is a definite relation between the length of the experimental period and the length and amplitude of the rhythmic pattern. The one hour subjects had longer rhythmic patterns than the two hour subjects, and the half hour subjects had rhythmic patterns longer than those of the one hour subjects. In regard to the amplitude and complexity of the rhythmic pattern we find just the opposite relation; the longer the length of the experiment the more complex the rhythmic pattern and the greater its amplitude.

As an explanation of this phenomenon we suggest that the performance is directed in part by a goal which functions in the control of nervous fatigue. In this problem the goal is to trace the maze pattern as rapidly and as accurately as possible and yet to continue throughout the time prescribed by the experiment. The organism compensates for a large expenditure of energy by relaxing. This tends to keep a certain balance or level of metabolic activity in the attainment of the goal tending to preserve the pattern until the goal is reached. The two hour subjects realize that they cannot keep going at their maximum rate of speed and be able to keep on for the entire two hours, and so they relax. This tends to keep a certain level of activity which rises and falls fairly often during the course of the experiment. The one hour subjects also adopt a relaxation pattern in order to be able to continue the maze tracing throughout the period of the experiment but as the time is shorter it is possible to maintain a more constant and faster pace. This causes the pattern to be more stable and so the rhythmic patterns are longer in extent and lower in amplitude. The half hour subjects know that they can keep going at almost their maximum speed for the entire course of the experiment and so they do not have to compensate for a large expenditure of energy by relaxing. They keep going at their maximum rate and the curve rises and falls very slightly; hence if the subjects exhibit rhythmic patterns they are relatively large in extent.

The Correlation of Direct Visual Perception of the Maze Pattern with Appreciable Improvement in Motor Efficiency

Some of the half hour subjects were shown the maze before they began their second period of tracing to see if a direct visual perception of the maze would cause an appreciable increase in the motor efficiency of tracing. The improvement which this group made on their second and third trialswas compared with the improvement on the second and third trials by a control group of half hour subjects who were not shown the maze. The results showed that direct visual perception of the maze was not followed by noticeable increase in motor efficiency. Possibly the subjects were not able to translate their visual image of the maze into a motor image; hence did not improve in performance. This agrees with the work of Bair (6) who found that subjects who had learned to respond to a certain definite serial order of color stimuli by a definite serial order of reactions on colored typewriter keys could not name over the series, but could respond to them in the order on the keys in the same way that he had learned them. The series can be reproduced only in the way it has been learned.

Summary of Introspective Reports

The introspective reports of the subjects throw no light on the significance of the rhythmic pattern for that particular subject and trial. The introspective reports are valueless for interpreting the subjects' performance for several reasons. First, there is no relationship between the subjects' reports as to the amount of trials they would complete, their feelings of emotional and muscular tonus and what they actually did accomplish as was shown by the time curve for that particular experiment. Second, in their reports as to the direction of the most rapid progress the subjects were wrong in nine cases out of ten. They seemed to be judging on the direction in which they made the most progress in accuracy; that is, the direction in which they avoided the niches along the sides of the groove. The report of subject Morrison, the most scientifically minded of the group, confirms this; she said in answer to the question as to direction of most rapid progress, "I made the best time going over but it seemed easier coming back." Third, the subjects would report a loss of the maze pattern, on trials which were considerably below the general average time required to trace the pattern. Therefore, the subjects' reports as to loss of pattern threw no light on the meaning of the level of the time curve for that particular experiment. Fourth, the subjects' reports on fatigued and rested periods was not correlated with the efficiency of performance, for the subjects in a great many cases would report a fatigue period at a point where there would be a sudden drop in the time curve. This is in line with the work of Thorndike (53) which points out that muscular fatigue is due to a diminished contraction of the muscles caused by continual contraction of the muscles through work. He further states that, "if an individual continues some performance in spite of his feelings of fatigue, the intensity of his feeling of fatigue is a very inadequate measure of his loss of efficiency -- the feeling of fatigue is a very poor symptom of the loss of ability." Therefore the subjects' introspective reports regarding feelings of fatigued and rested periods throws no light on the amplitude and frequency of the rhythms for that particular subject and trial.

The introspective reports of the subjects as to the easy and the difficult portions of the maze were very accurate at first, but in the later trials they would report as hard those parts of the maze which were in reality the least difficult from a standpoint of complexity and would report as easy those parts of the maze which they had previously reported as giving them the greatest difficulty. A possible explanation of this factor may lie in the fact that the subjects showed little improvement in the speed for those parts which were easy for them at the beginning of the experiment, but showed considerable improvement in the time required for tracing those parts which gave them the greatest difficulty at first. The increase in efficiency in the parts with no improvement in efficiency for the easy parts probably caused the hard parts to appear easy by comparison. This is in line with the findings of Snoddy (51) who pointed out that in the mirror tracing experiment his subjects showed no improvement in those parts which were eas and which gave them the greatest amount of 'pleasure', and that they showed great improvement in those parts which were the most difficult and gave them the most 'dis-pleasure'. The theory of pain-pleasure seemed to throw no light on the improvement in the various parts of the maze in this experiment.

Relation of the Degree of Incentive to the Length and Amplitude of the Rhythmic Pattern

Comparing the curves of the subjects who worked under different incentives and with varying degrees of effort we find no relation between incentive and the length and amplitude of the rhythmic pattern. This is quite in line with the findings of Roff (45) and Pankratz (35) who pointed out that there is no direct relation between the degree of effort and success in a motor performance.

A Study of Periodicity without Learning

Do the Work Curves Obtained from the Square Tracing Board Reveal Rhythmic Patterns?

Since the apparatus used by Wheeler (58) in his original study and by the author in the earlier part of this experiment seemed to involve some degree of learning we wished to ascertain to what extent the rhythmic patterns obtained in those experiments were the result of the learning involved. The simple square tracing board described earlier was used in this experiment.

The curves of subject Kerchner (Figure 15) show rhythmic patterns much like those from the first maze. The first week the total number of completions of the maze pattern was 375. The curve showed no major slants. The major high points were 54 (54), 104 (50), 159 (55), 206 (47), 258 (52), and 315 (57). The major low points were at 123 (123), 242 (119), and 351 (109). Since the major low points are not as regular as the major high points we have judged the rhythms in this part of the experiment largely in terms of the pattern from high to high point. The major rhythms in this curve appear to be of the same extent as the major high points, that is 54, 50, 55, 47, 52, and 57. Certain definite minor rhythms stand out very clearly in this curve. They occur regularly and have about the same extent

Square Tracing Curve.
Subject: Kérchner

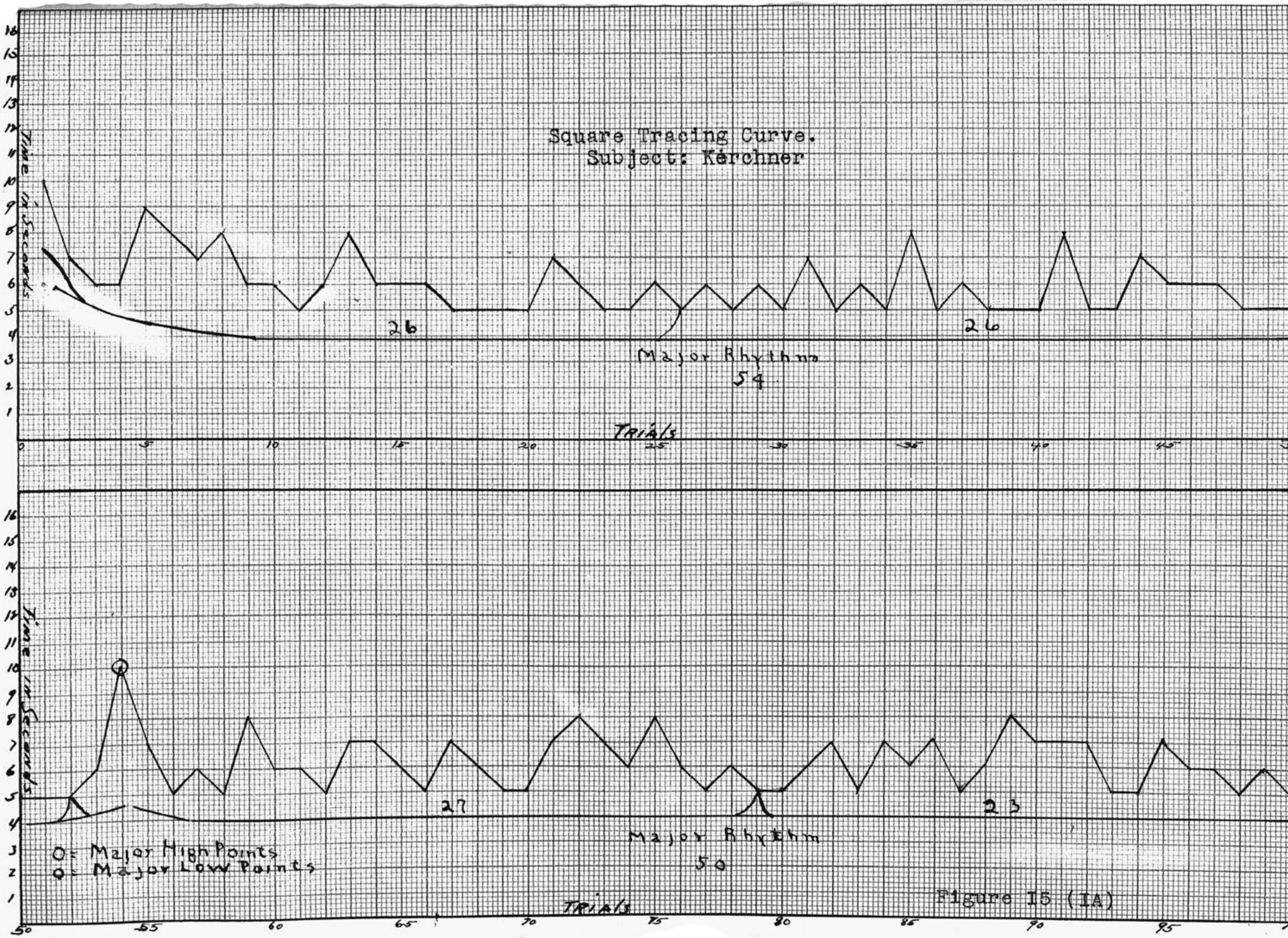


Figure 15 (IA)

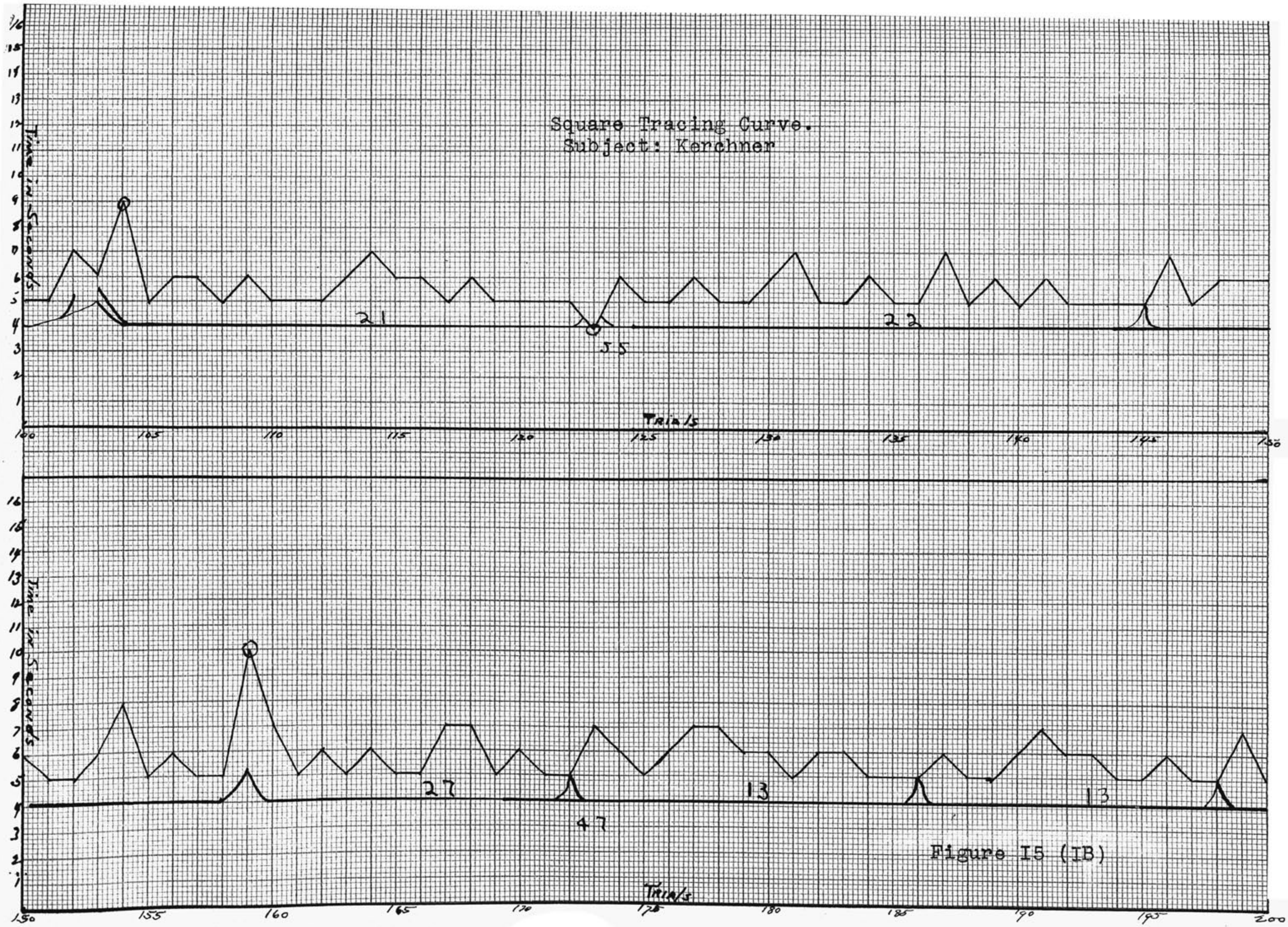
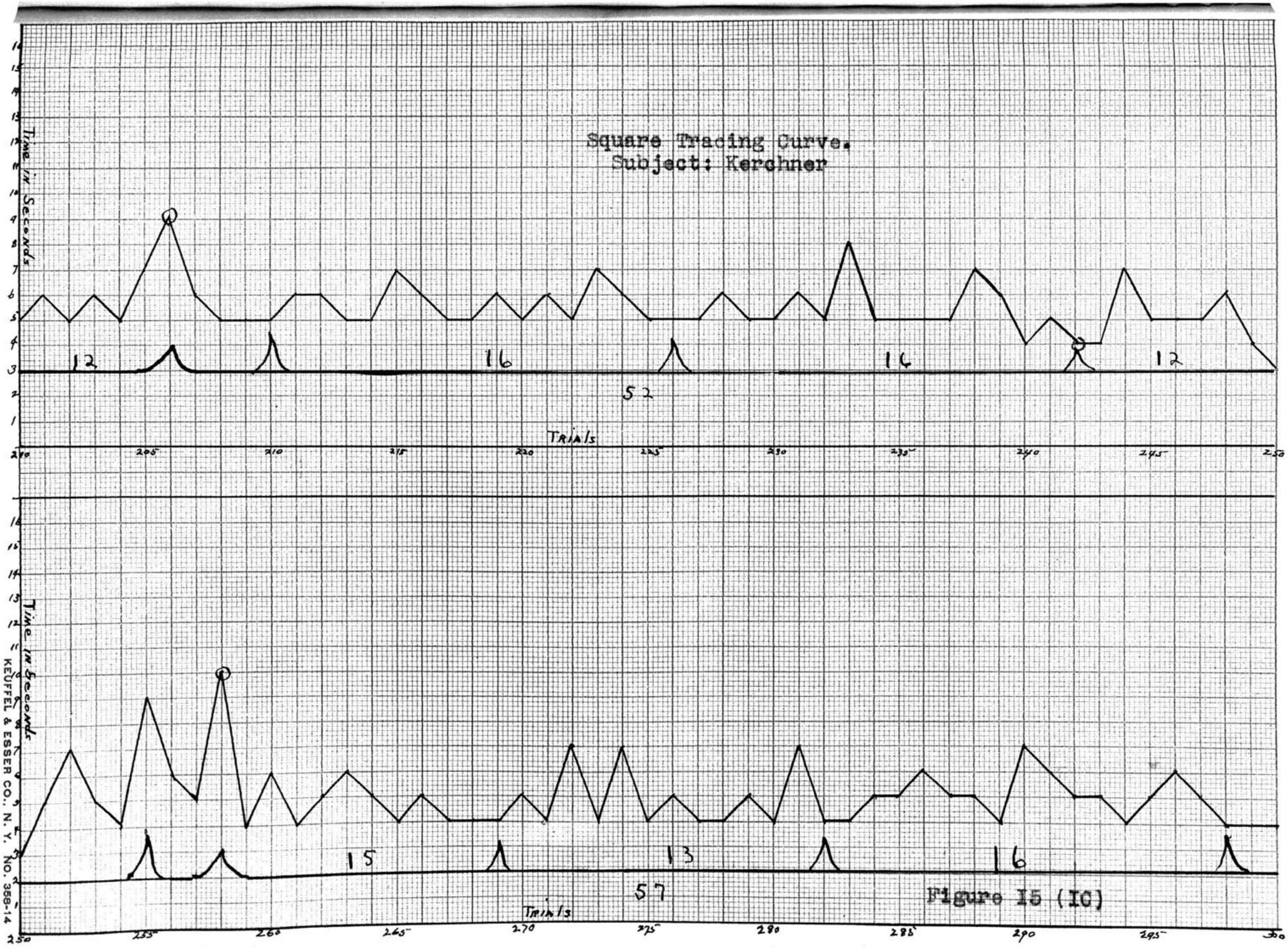

Square Tracing Curve.
Subject: Kerchner
Time in Seconds
Trials
21
22
55
27
13
13
47
Time in Seconds
Trials

Figure I5 (IB)


Square Tracing Curve.
Subject: Kerchner
Time in Seconds
Trials
12
16
16
12
52
Time in Seconds
Trials
15
13
16
57
Figure 15 (IO)

Square Tracing Curve.
Subject: Kerchner

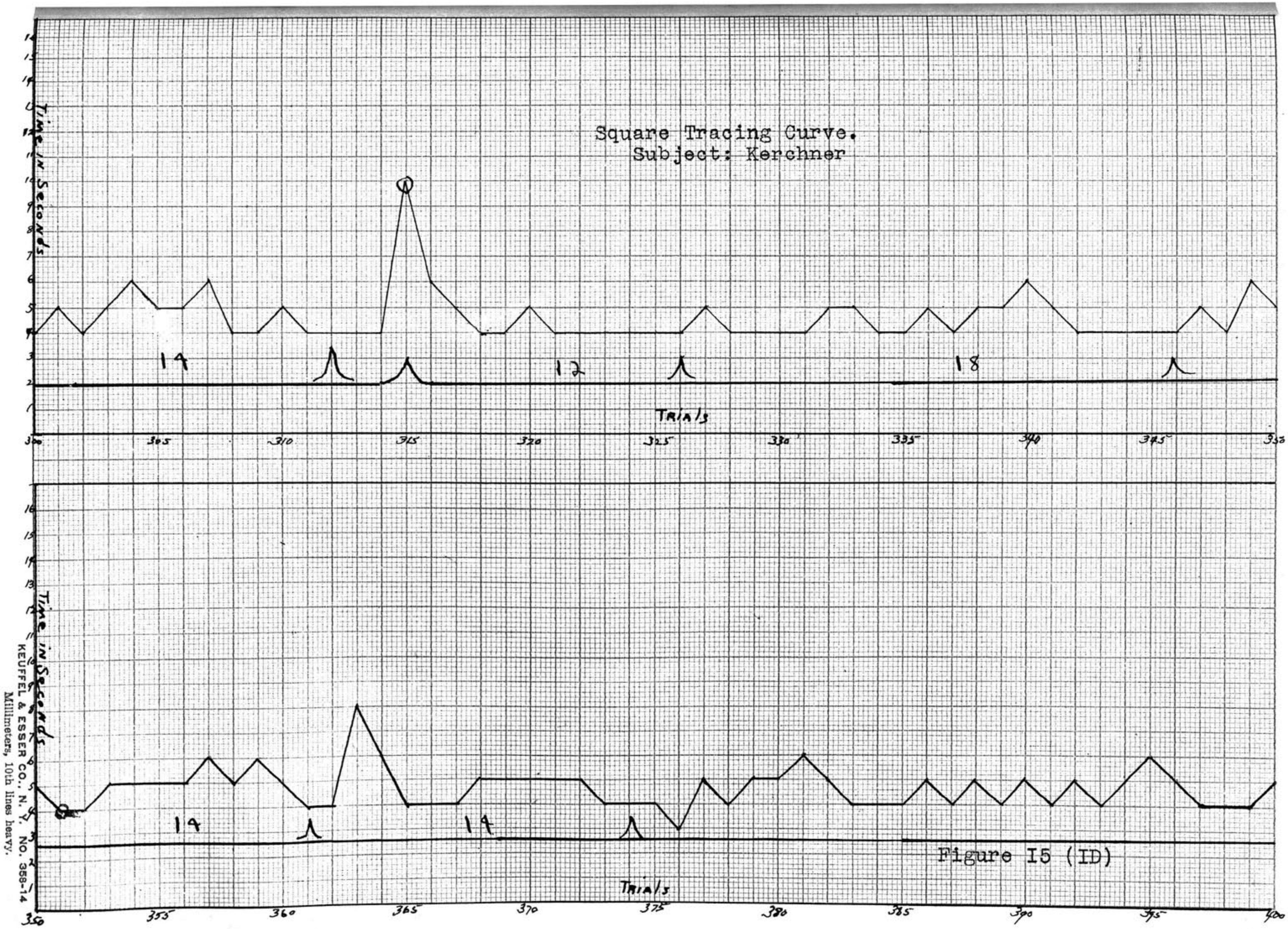
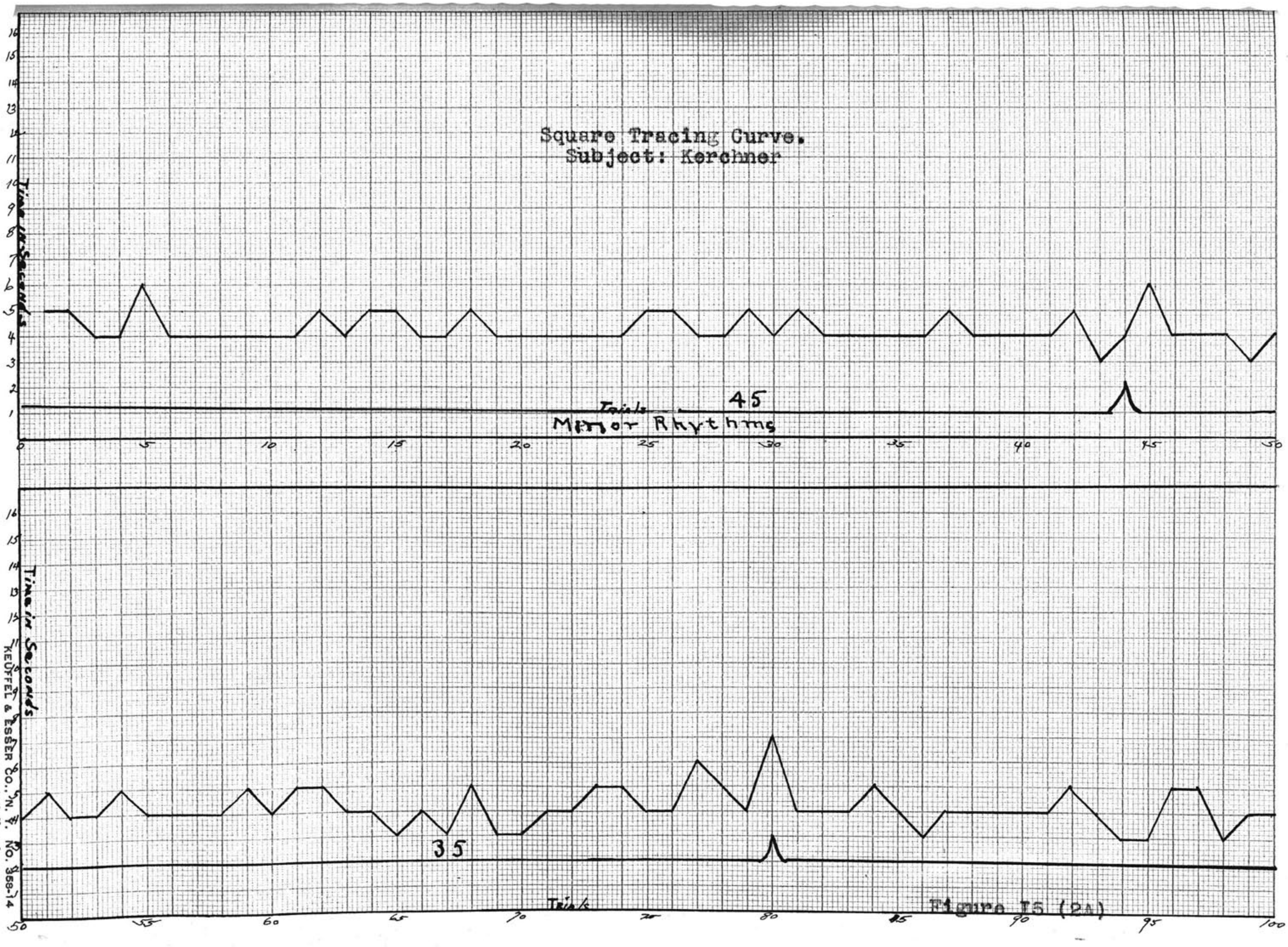
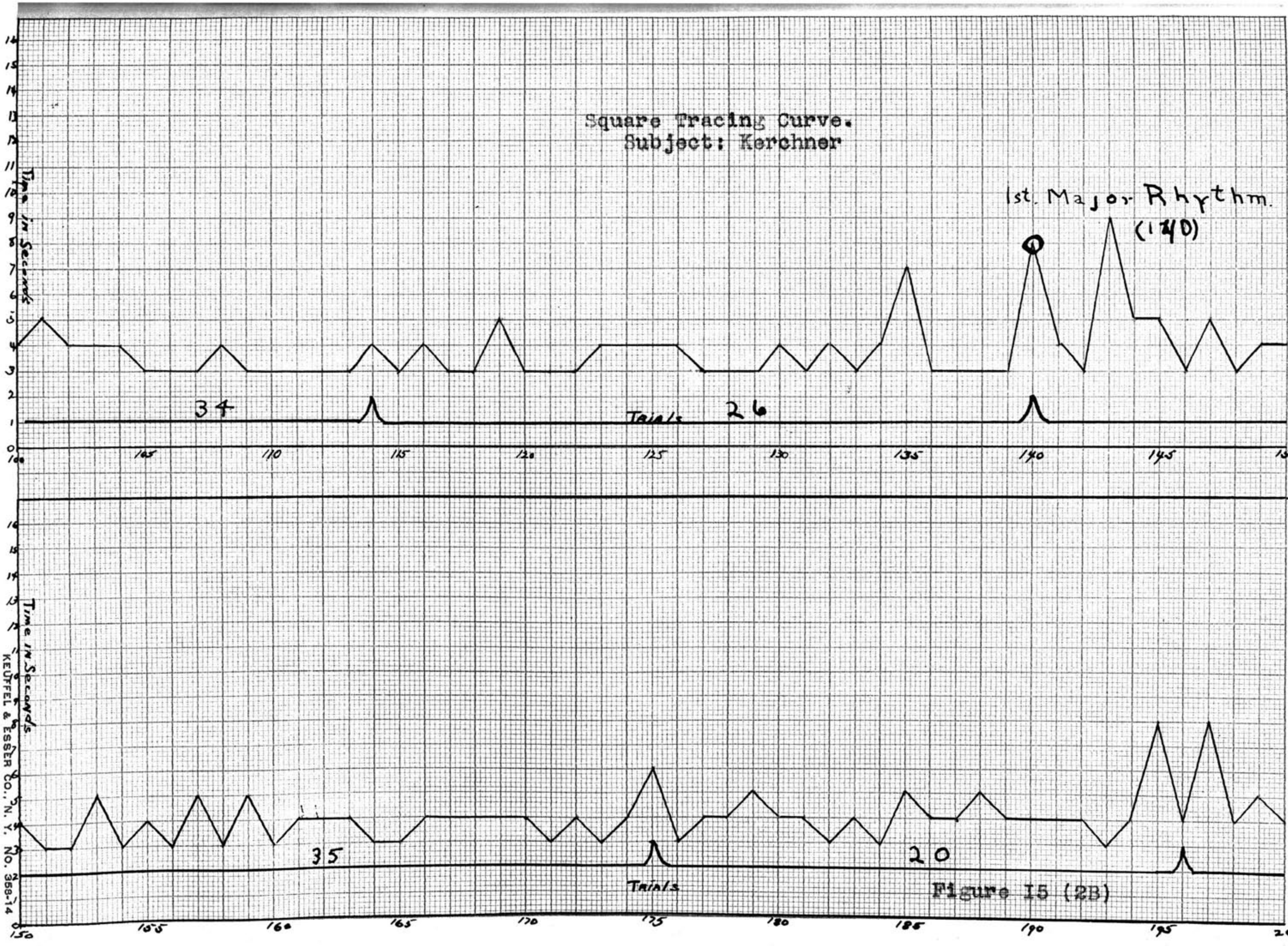


Figure I5 (ID)



Square Tracing Curve.
Subject: Kerchner
Time in Seconds
Trials
45
Minor Rhythms
Time in Seconds
35
Trials
KEUFFEL & ESSER CO., N. Y. NO. 358-14
Millimeters, 10th lines heavy.

Figure 15 (2A)


Square Tracing Curve.
Subject: Kerchner
1st. Major Rhythm.
(140)
Time in Seconds
Trials
34
26
35
20
KEUFFEL & ESSER CO., N. Y. NO. 358-14
Millimeters, 10th lines heavy.
Figure I5 (2B)

Square Tracing Curve.
Subject: Kerchner

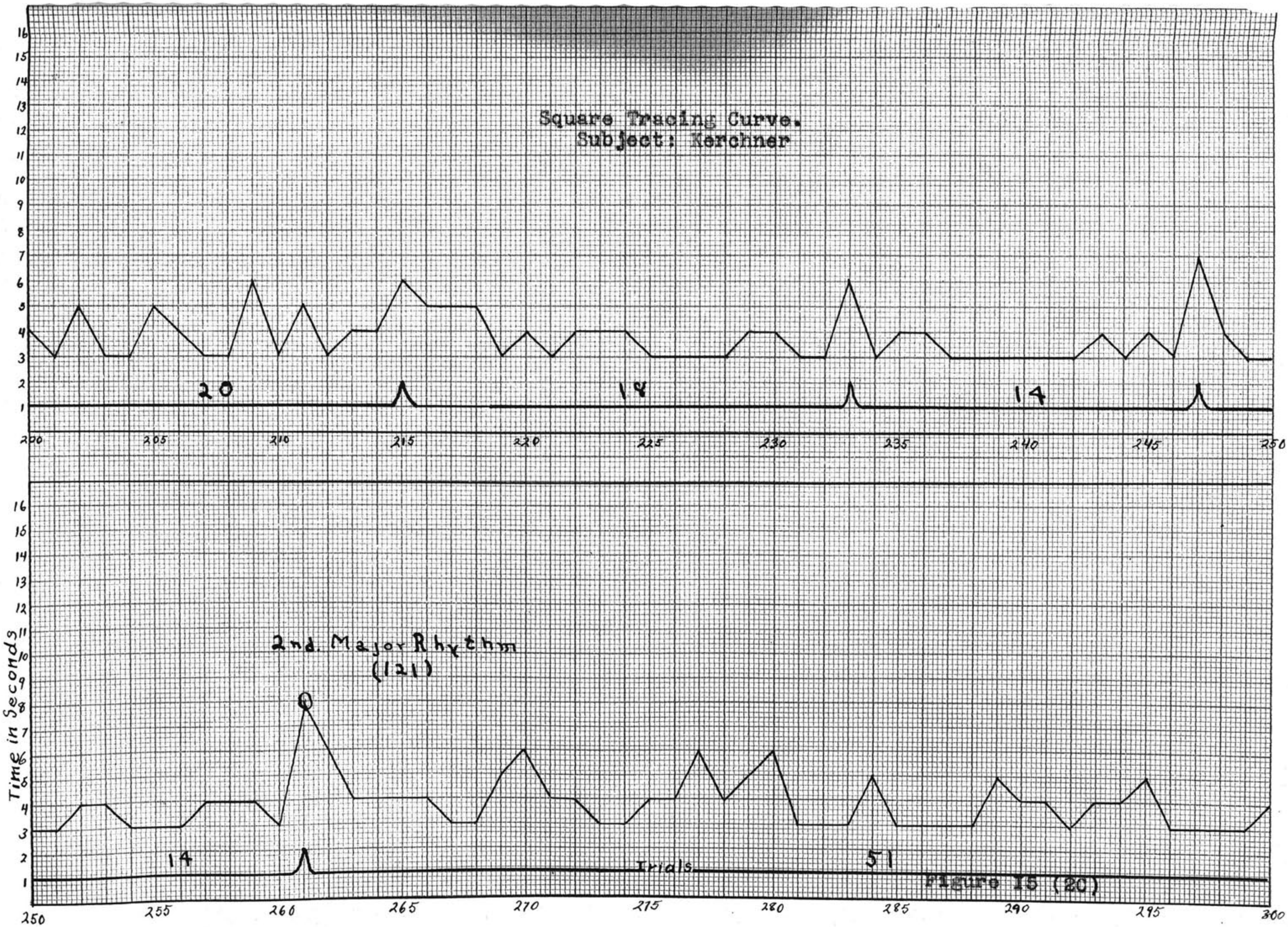


Figure 15 (20)

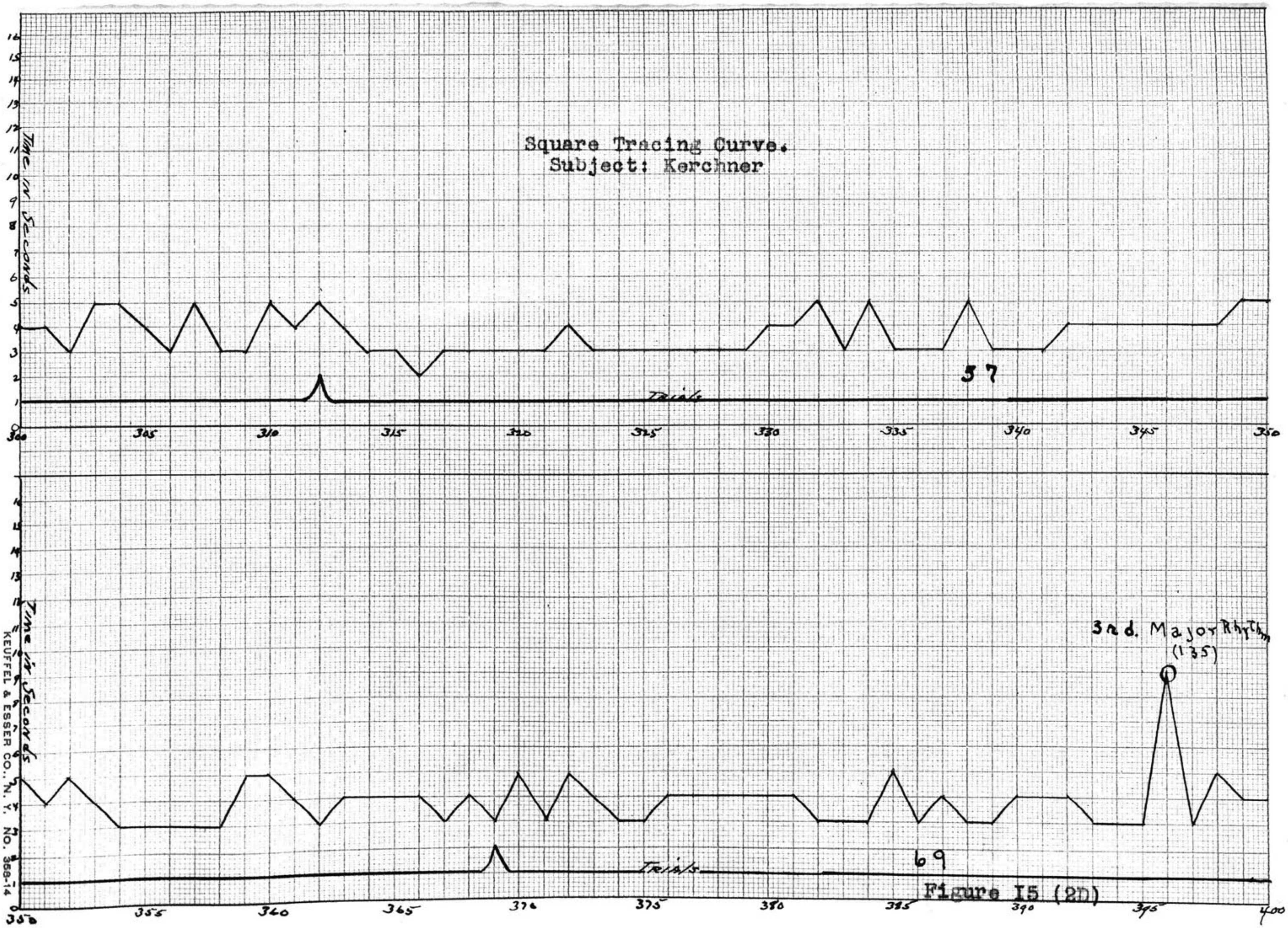


Figure 15 (2D)

KEUFFEL & ESSER CO., N. Y. NO. 358-14
Millimeters, 10th lines heavy.

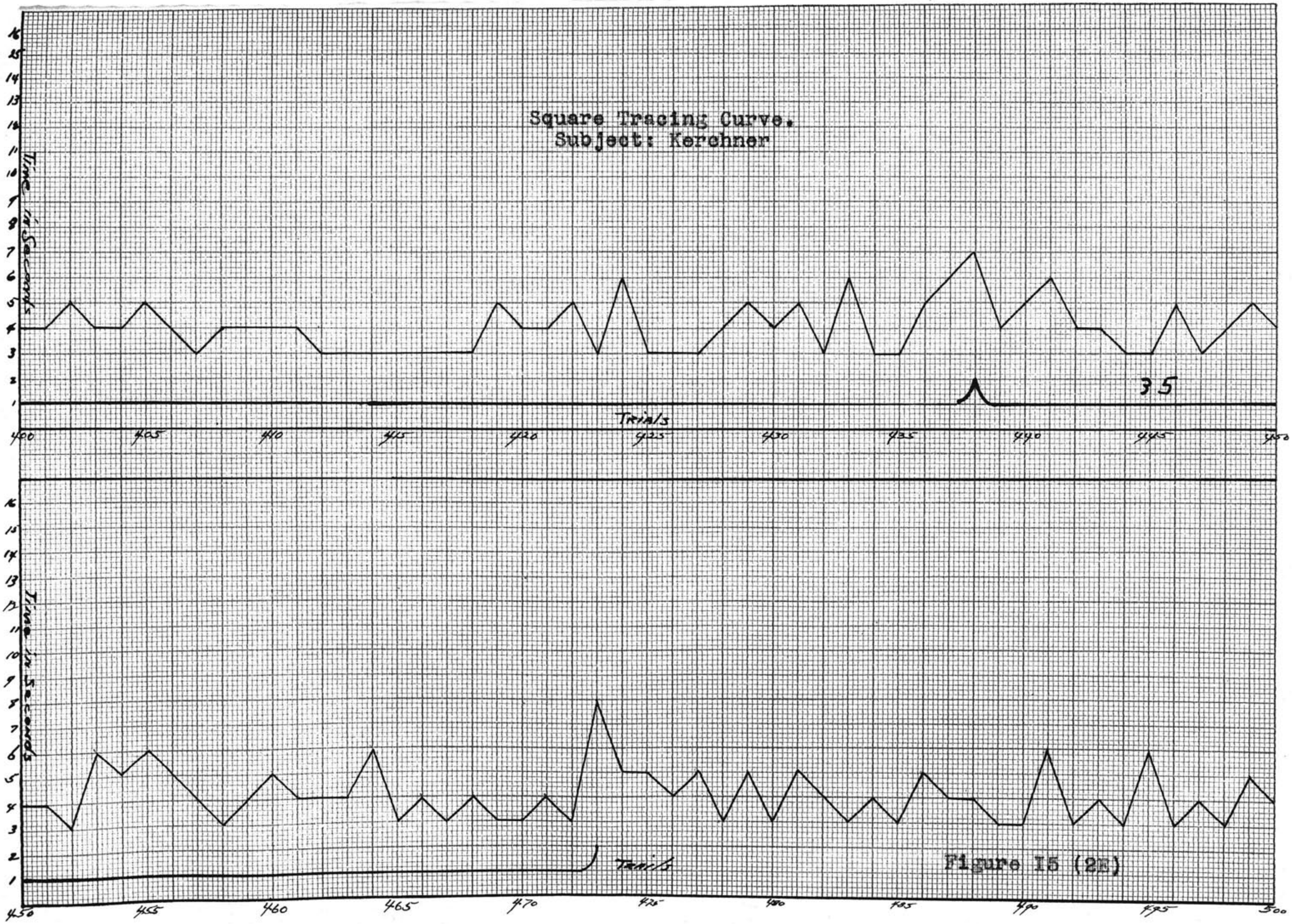

Square Tracing Curve.
Subject: Kerchner
Time in Seconds
Trials
35
400
405
410
415
420
425
430
435
440
445
450
Time in Seconds
Trials
450
455
460
465
470
475
480
485
490
495
500

Figure 15 (2E)

Square Tracing Curve.
Subject: Kerchner

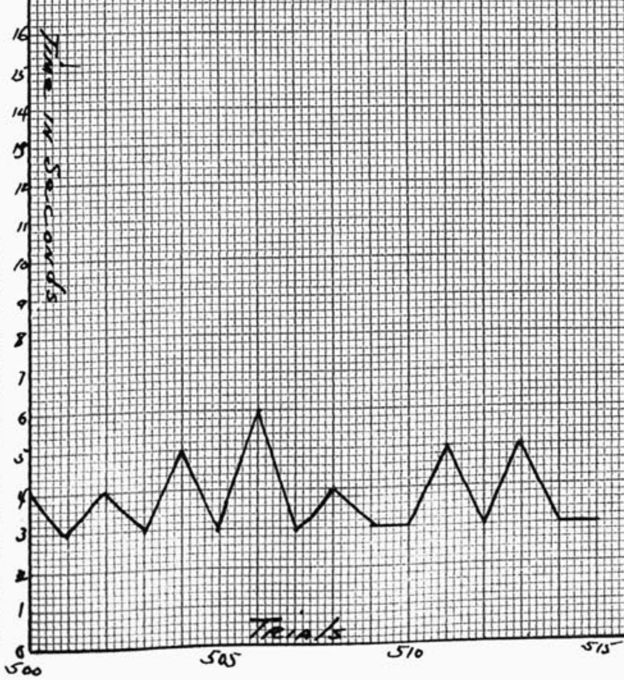


Figure 15 (2F)

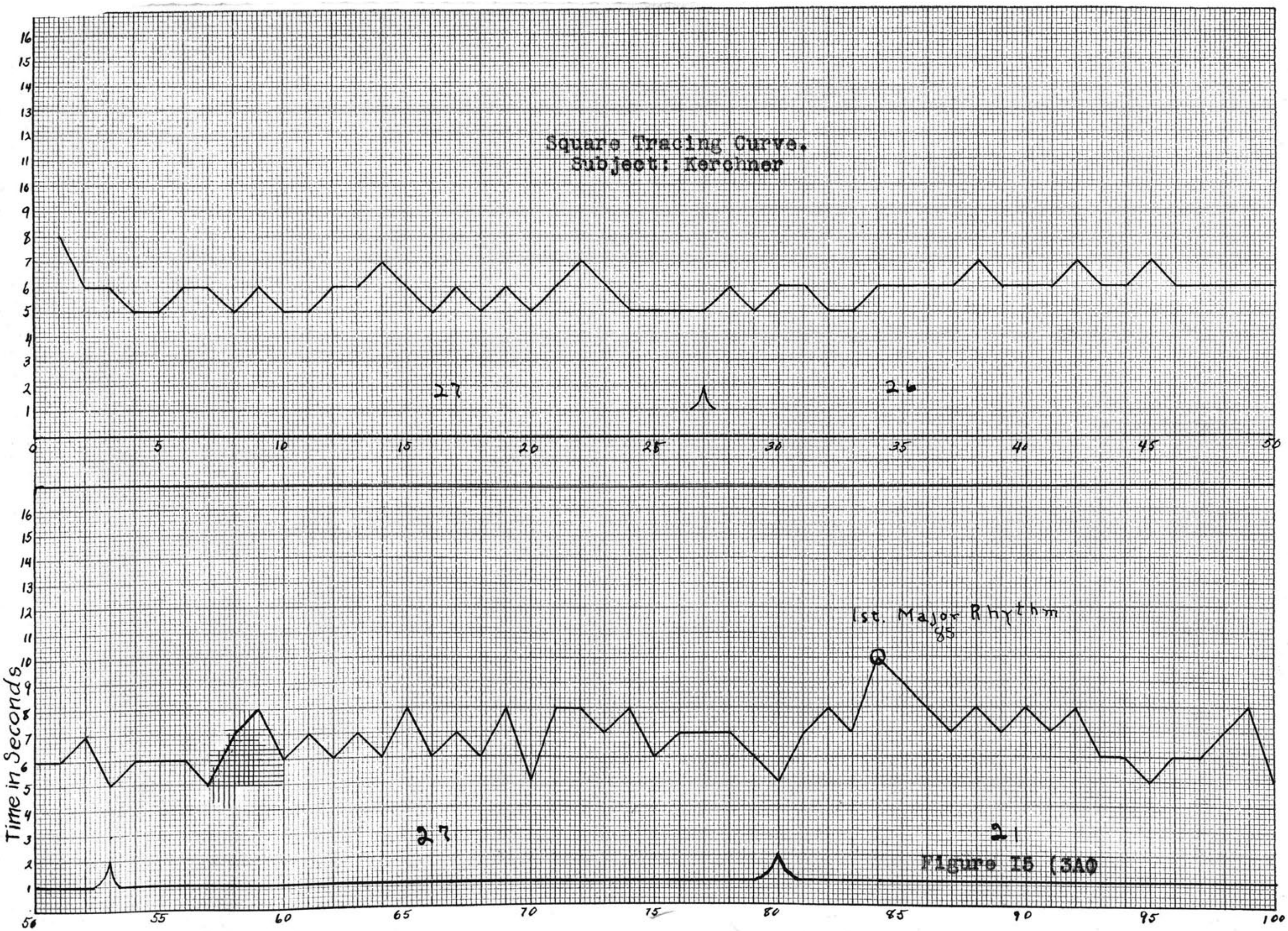


Figure 15 (3A0

Square Tracing Curve.
Subject: Kerchner

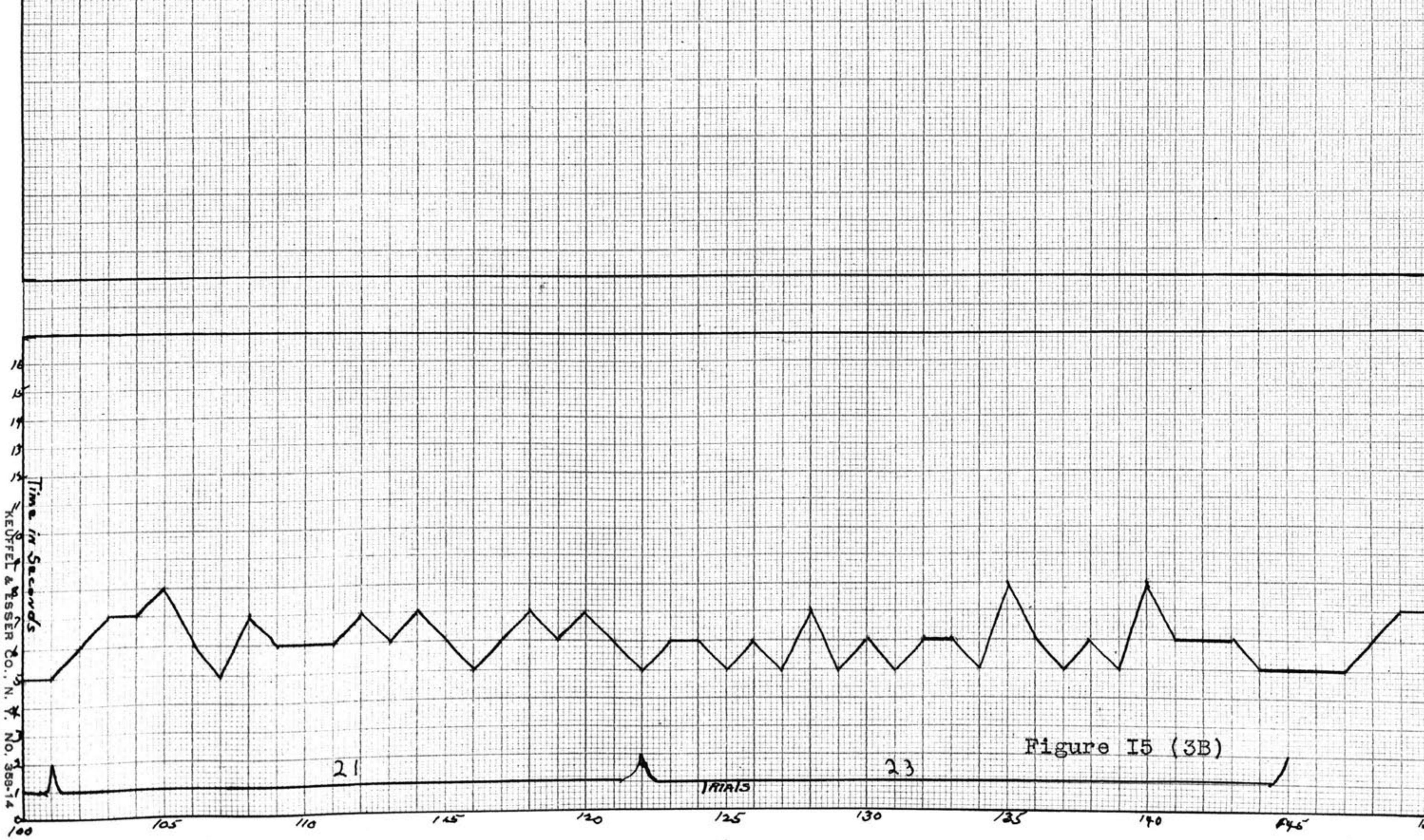
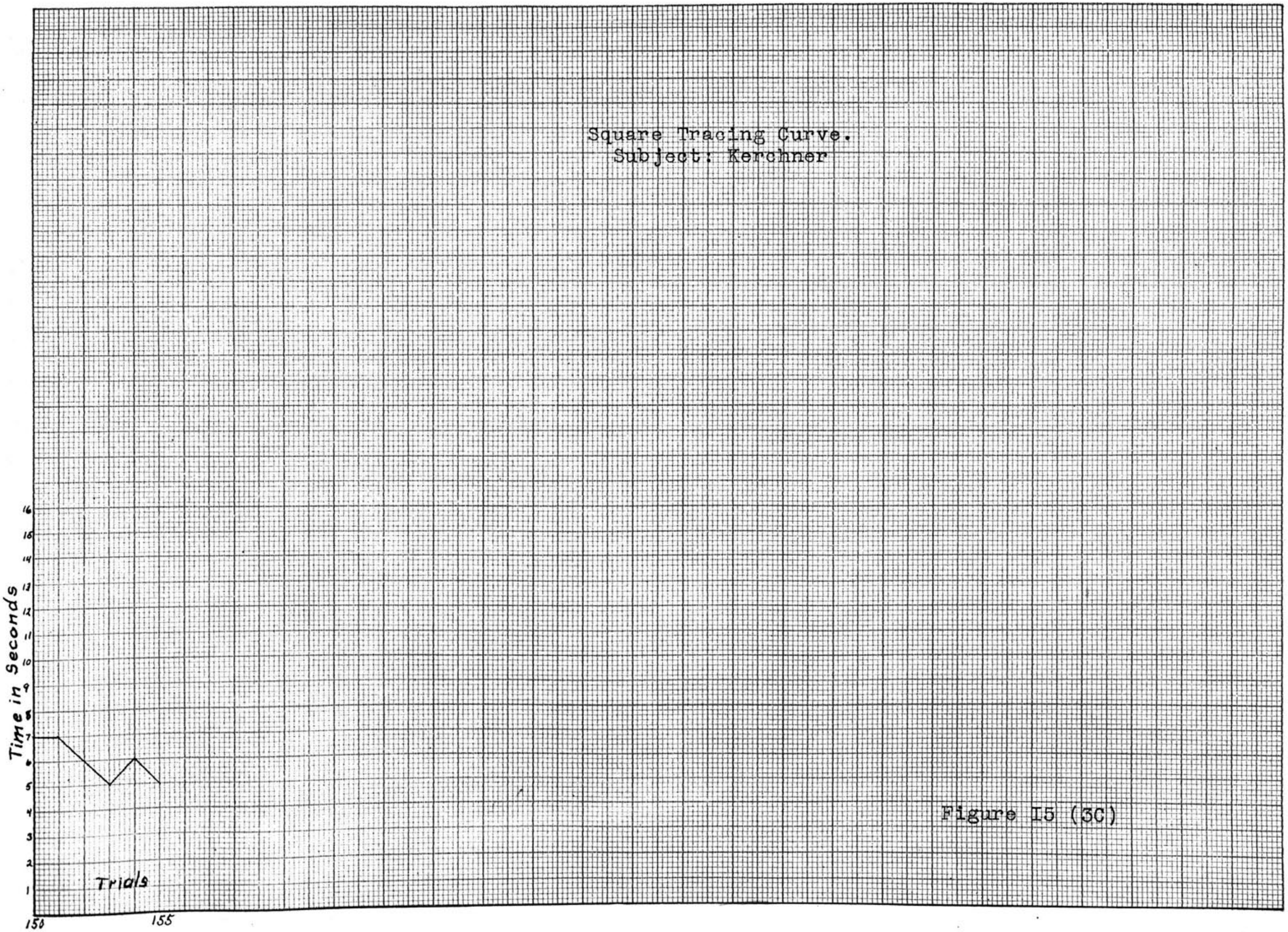


Figure I5 (3B)



Square Tracing Curve.
Subject: Kerchner

Figure I5 (3C)

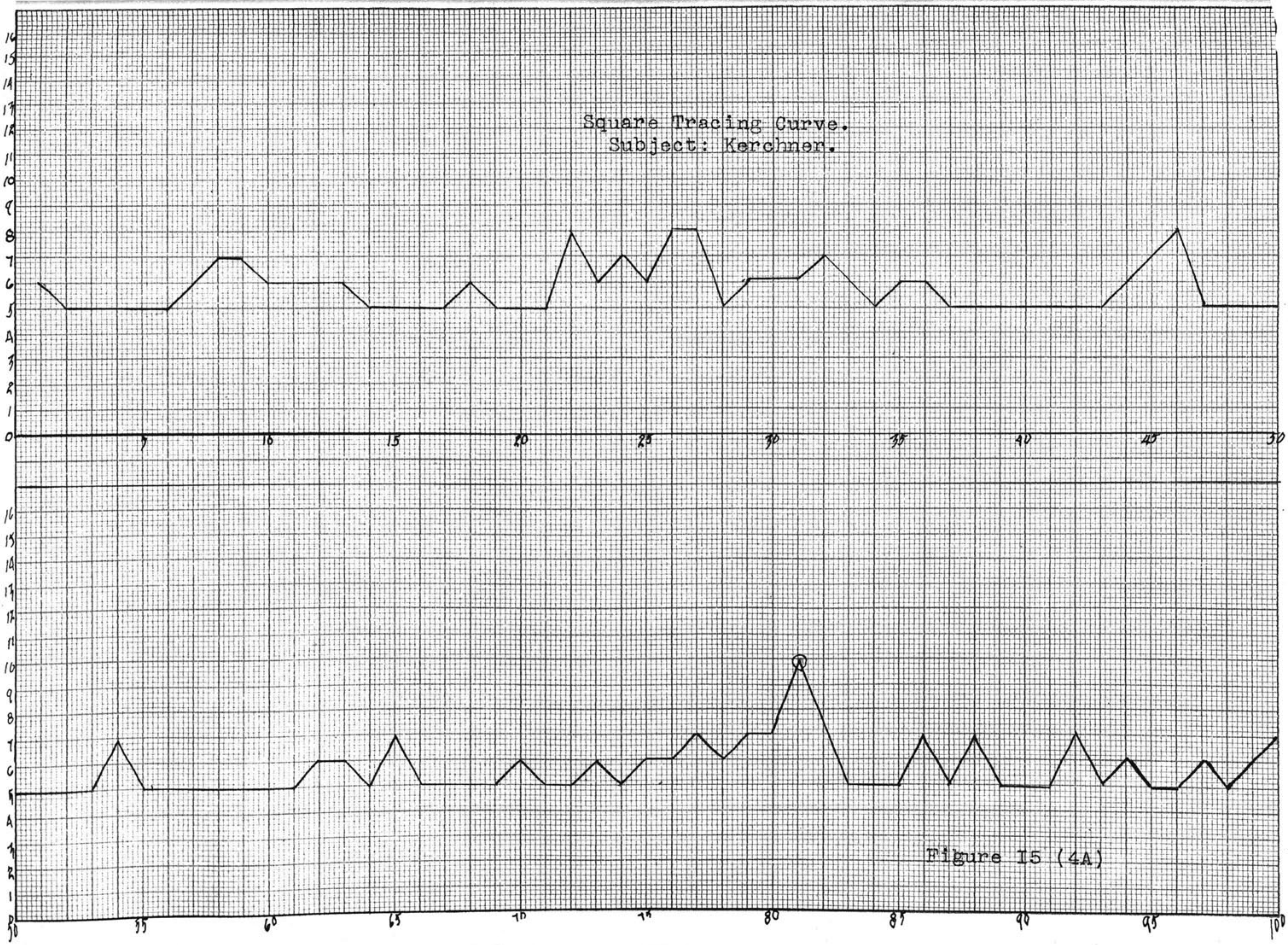
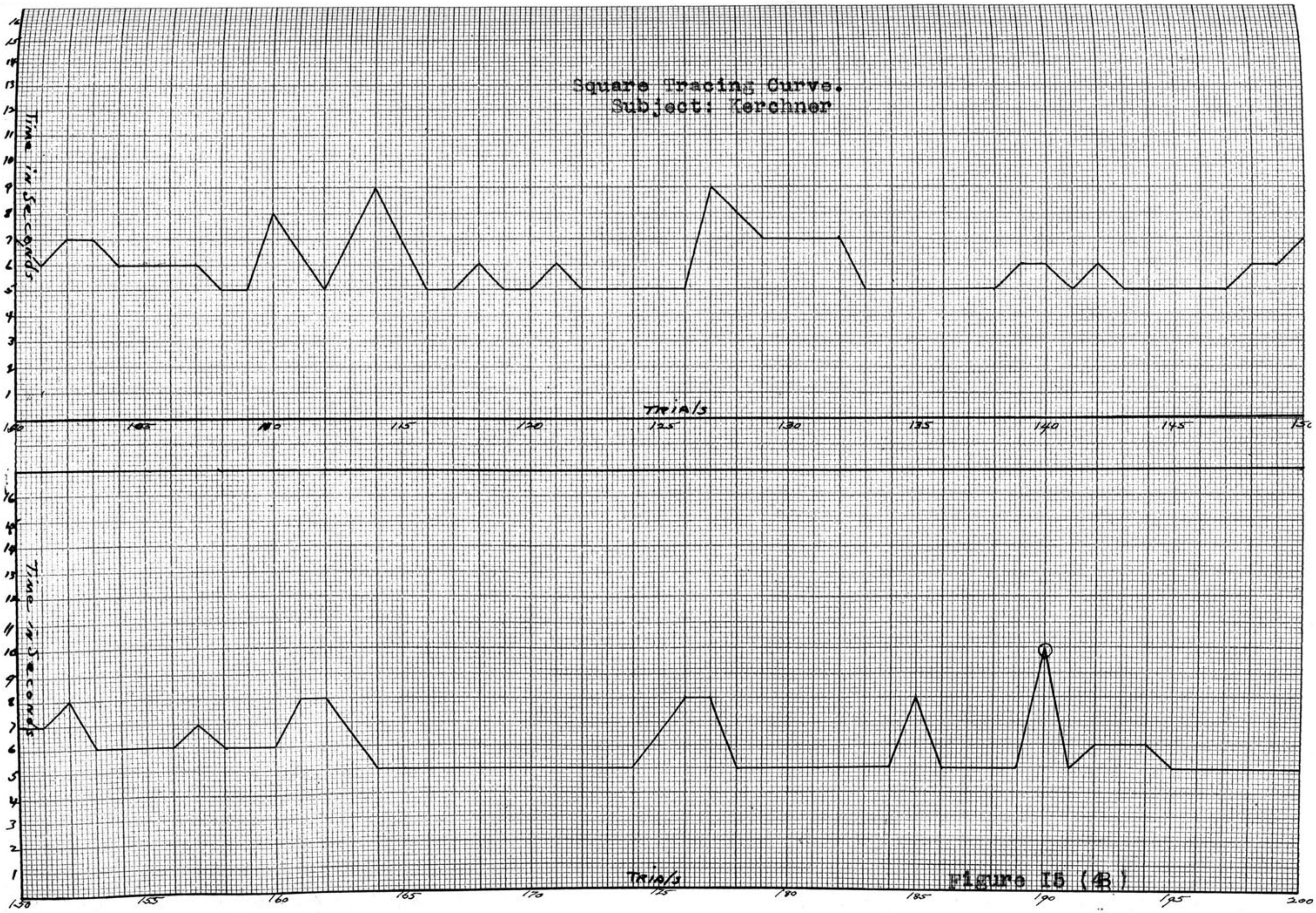

Square Tracing Curve.
Subject: Kerchner.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

Figure I5 (4A)



Square Tracing Curve.
Subject: Kerchner

Figure 15 (4B)

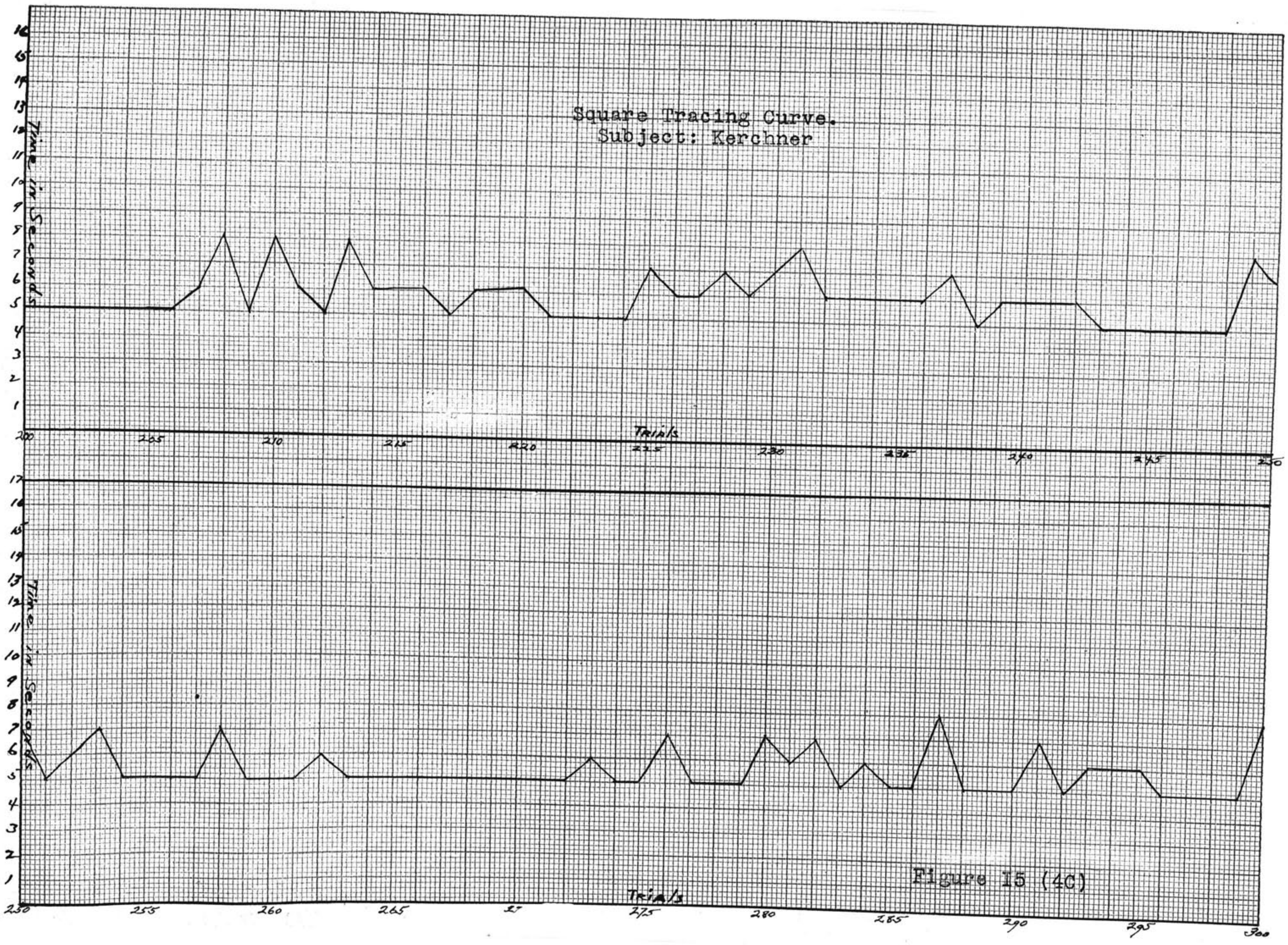

Square Tracing Curve.
Subject: Kerchner
Time in Seconds
Trials
Time in Seconds
Trials

Figure 15 (4C)

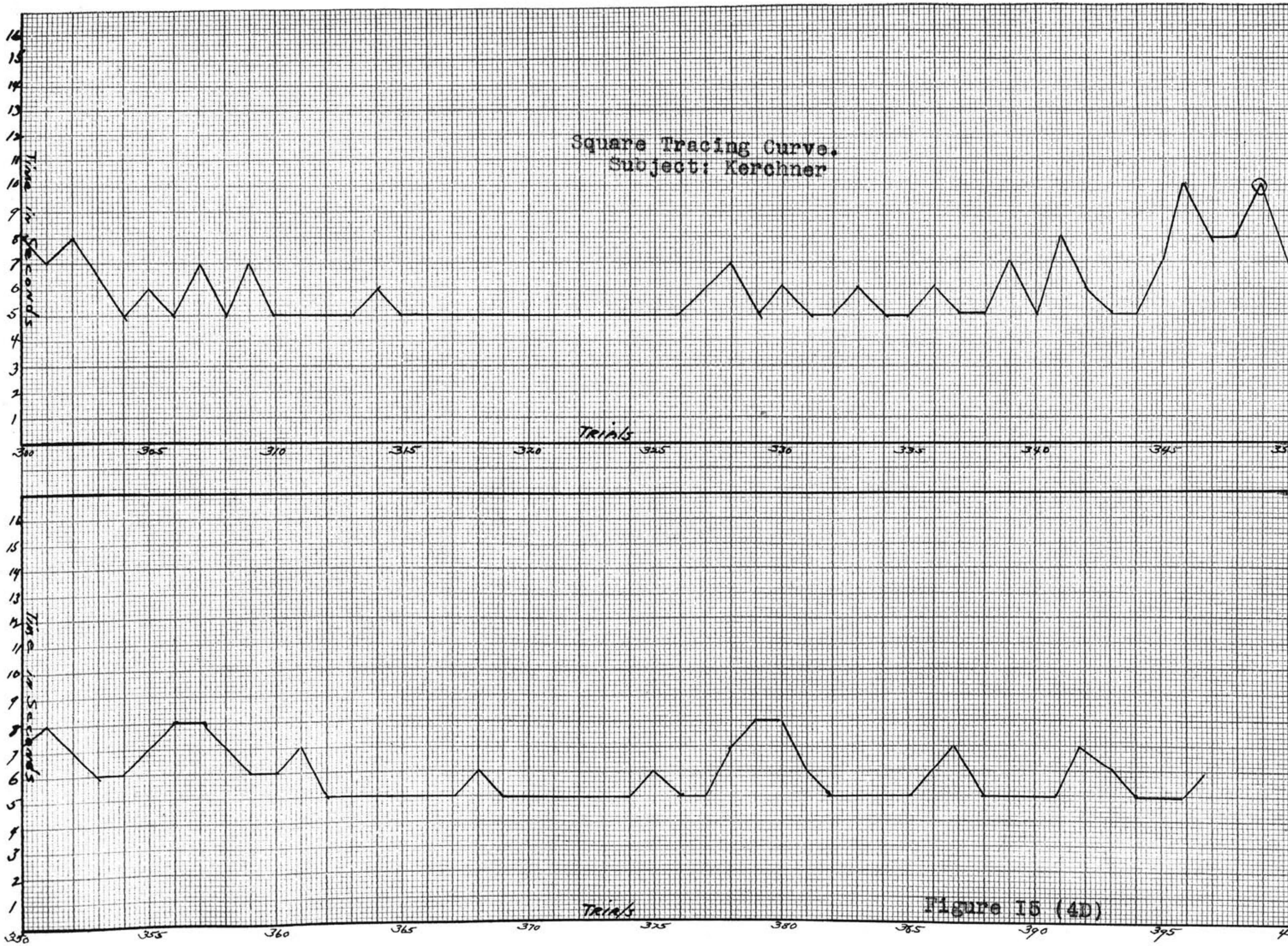

Square Tracing Curve.
Subject: Kerchner
Time in Seconds
Trials
300
305
310
315
320
325
330
335
340
345
350
Time in Seconds
Trials
350
355
360
365
370
375
380
385
390
395
400

Figure 15 (4D)

until toward the middle of the curve where the longer minor rhythms tend to break down into smaller ones. We can, however, break up these larger minor rhythms which we found in the first part of the experiment into two smaller rhythms which have almost the same extent as the small minor rhythms which we find after the middle part of the curve has been reached. These minor rhythms appear at the following points: 26 (26), 52 (26), 79 (27), 102 (23), 123 (21), 145 (22), 172 (27), 185 (13), 198 (13), 210 (12), 226 (16), 242 (16), 254 (12), 269 (15), 282 (13), 298 (16), 312 (14), 326 (12), 344 (18), 360 (14), and 374 (14). The larger minor rhythms of 26, 26, 27, 23, 21, 22, and 27 break up into the following smaller minor rhythms: (11, 15), (13, 13), (14, 13), (13, 10), (10, 11), (11, 11), and (14, 13).

The curve for the second week also shows definite rhythmic patterns. The total number of completions of the maze pattern is 515. The major high points are as follows: 140 (140), 261 (121), and 396 (135). The curve shows no major slants. The major low points seem to be covered up by the increase in the efficiency in the maze tracing; all the low points tend toward a common base-line. The major rhythms appear to have the same extent as the major high points, that is 140, 121, and 135. The curve shows very definite minor rhythms whose extent is shown by the following points: 45 (45), 80 (35), 114 (34), 140 (26), 175 (35), 195 (20), 215 (20), 233 (18), 247 (14), 261 (14), 312 (51), 369 (57), 438 (69), and 473 (35). On the last part of the curve we find the smaller rhythms changing into the larger rhythms which are about equal to two of the smaller rhythms.

The curve for the third week is of somewhat doubtful value since the subject who was very vigorous in her movements broke the apparatus at trial 155. The curve shows no major slants. The major high points fall on the eighty-fifth trial. No major low points appear in the curve. The major rhythm as judged from high point to high point appears to fall on trial 85. Certain definite minor rhythms appear despite the fact that the apparatus broke down. The minor rhythms fell on the following points, 27 (27), 53 (26), 80 (27), 101 (21), 122 (21), and 145 (23). Each major rhythm seemed to have three minor rhythms, (27, 26, 27) and (21, 21, 23). The curve tends to flatten out. We find the appearance of major rest periods.

In the curve for the fourth week we note the absence of major slants, major low points, and, also, we are unable to point out either major or minor rhythms. We do notice some variability in the work curve and find certain major high points at the following trials, 82, 190, and 348.

While the curve of subject Williams (Figure 16) shows no major slants, major high points, or major low points it still exhibits definite major and minor rhythms. The

Square Tracing Curve.
Subject: Williams

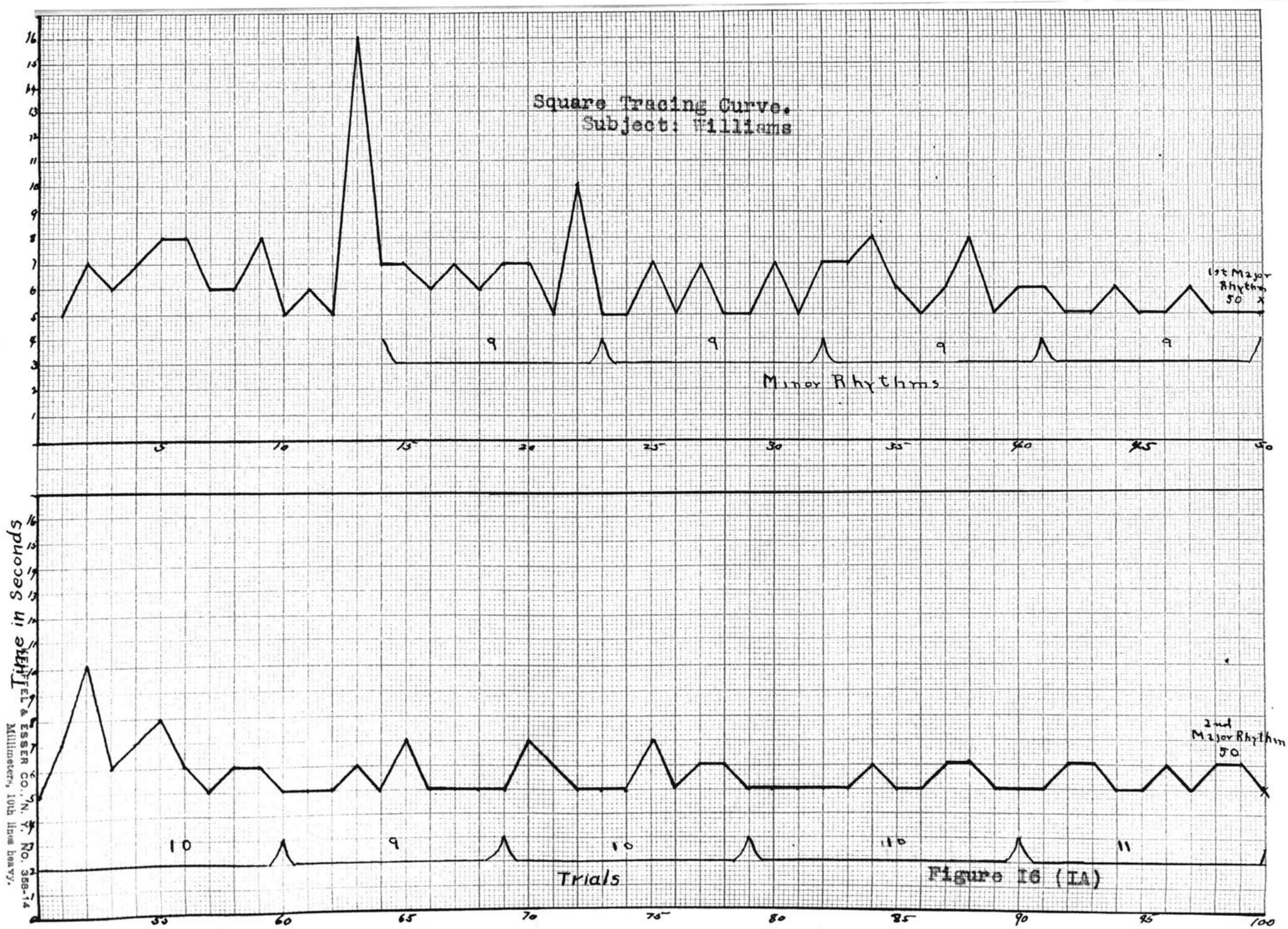


Figure 16 (IA)

Square Tracing Curve.
Subject: Williams

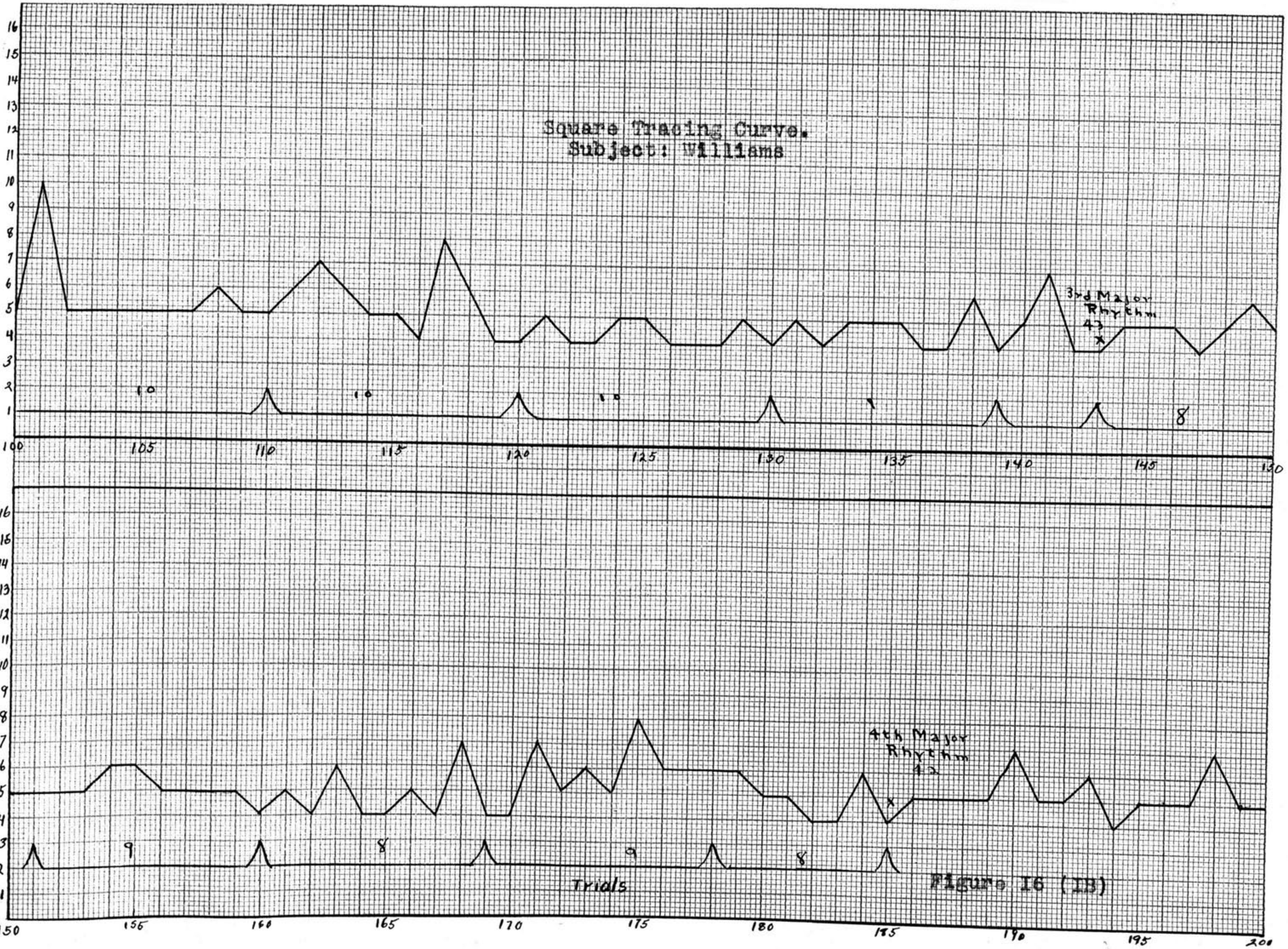


Figure I6 (IB)

major rhythms fall on the following points: 50 (50), 100 (50), 143 (43), and 185 (42). The first major rhythm of 50 contains the following minor rhythms: 9, 9, 9, 9. The second major rhythm contains the following minor rhythms: 10, 9, 10, 10, 11. The third major rhythm contains the following minor rhythms: 10, 11, 10, 9, 5. The fourth major rhythm is composed of the following minor rhythms: 8, 9, 8, 9, 8.

There is no correlation between the subjects' introspective reports of fatigue and rested periods and the efficiency shown at that time in the motor performance.

We do find evidence for the existence of rhythmic patterns in simple motor performances that do not involve learning. The rhythmic pattern is, however, less complex, lower im amplitude, but greater in extent. The pattern is more subject to modification over a period of time than are the rhythmic patterns which we obtain in the performances which involve learning. Several things distinguish these curves from the curves in the more complex experiment: first, the major high and low points are not as frequent nor as significant as in the other type of problem. Second, major slants seem to be absent from these curves. Third, the rhythmic pattern disappears more quickly than in those curves of performance which involve learning. Fourth, we find early appearance of major rest periods.

VI. SUMMARY AND INTERPRETATIONS

1. The curves showed major rhythms of approximately equal length throughout the curve for each period of tracings. When the rhythm shortened, it seemed shorter only by the amount of a minor rhythm.

2. These rhythms seemed to persist over a considerable period of time. The general level of the curve may fall, but the form of the curve remains relatively constant. As time went on, the major high points dropped; the major rhythms spread out as though the curve had been flattened. The major low points tended to disappear as learning increased. As the learning process progressed there appeared major rest periods. These may be periods in which the state of muscle coordination and nervous impulses were best balanced. These rest periods continued to grow larger until the rhythms seemed to disappear and the time curve approached a straight line.

3. The curves show no evidences of 'initial' or 'end-spurts', or of a 'warming-up period'.

4. There is no relationship between increasing efficiency in tracing the maze and accuracy of the visual image as shown by the drawings.

5. The length and amplitude of the rhythmic pattern seemed to depend on the length of the experimental period.

The longer the experimental period the greater is the amplitude and the less the extent of the rhythmic patterns.

6. Direct visual perception of the maze does not seem to be correlated with appreciable improvement in motor efficiency. Subjects are unable to translate visual images into motor images.

7. The subjects' introspective reports throw no light on the significance of the rhythmic pattern.

8. Evidence points to the existence of rhythmic patterns in performances which do not involve learning as well as in performances which do involve learning. The rhythmic patterns in the non-learning performances are less complex, have fewer phases and are more spread out than in performances which involve learning. The rhythms disappear more quickly in non-learning performances than in those which involve learning.

9. The degree of incentive and the degree of effort have no appreciable effect on the level of the curve of performance for that particular problem.

An explanation of these rhythms probably involves the following factors: <u>the complexity of the task</u>, for the more complex the task the more complex the rhythms and the greater their amplitude and extent; the <u>amount of organism involved</u>, for the complexity of the rhythmic pattern seems to vary directly with the amount of the organism involved; the <u>degree of differentiation of the subject</u>, for as has been pointed out in regard to the lower animals they present no periodicity of performance until they become relatively differentiated; the rhythms of the nervous impulses; on the physiological side periodicity may be associated with variations in the general relationship between energy-building and energy-spending involving (1) metabolic activity, (2) sex and other ductless glands, (3) functioning of the autonomic nervous system. In other words these are subject to daily variations about a moving axis which in turn has a cyclical periodicity.

The writer suggests the following general theory, with acknowledgments to several experimental investigators, especially Richter, Allen, Hersey and Wheeler. Until the organism becomes relatively differentiated we find no evidences of rhythms. When, however, the neuro-muscular system becomes differentiated we find rhythms which seem to be influenced by the oscillatory effect of the nerve impulses. There are both enhancing and inhibitory phases of these impulses. When the inhibitory predominates, stimulation may produce stationary or even diminished results. When this phase is followed by the enhancing phase, further stimulation again becomes effective in raising the level of the curve of performance. The breathing places on the work curve are due to inhibitory phases of more rapid neural oscillations of short duration, and the plateaus or major rest periods to those of long period oscillations.

The completed performance is the unit. The performance is directed in part by a goal which functions in the control of nervous fatigue. The organism compensates for a large expenditure of energy by relaxing. This tends to keep a certain balance or level of metabolic activity in the attainment of the goal tending to preserve the pattern until the goal is reached. It takes a long time to reach the goal and the level of the curve rises and falls. Time is subordinate to the goal, and the performance is on the 'all-or-none' principle as far as output is concerned.

The present study of rhythms throws light on certain studies made in the field of psychology from different viewpoints.

Hartman (22) attempted to find the reliability of initial performance as a basis for predicting ultimate achievement. Using the method first suggested by Bair (6) to measure the speed of verbilization he obtained the following results. Correlation of the means of the first three and last three trials of each record gave coëfficients of moderate size. The constancy of the values seemed to justify the assertion that the size of the initial score provided a reasonably good prediction of the final score, at least within the limits of the experiment. They did not know whether the situation would be altered with an extension of the trials. In the light of the present study it would seem quite important that the rhythm of the subject should be investigated as a whole, for if the first three trials selected were at a point where there was a tendency toward maxima and the last three when there was a tendency toward minima there would be a very poor correlation. Our study seems to show, however, that if we have the first two rhythms of the subject we can predict the general pattern of his forthcoming responses.

Lennes and Fee (29) set out to find how nearly uniform in their performances are the most consistent performers and how greatly do the most inconsistent vary in in this respect. Their study was purely statistical and gave them little knowledge as to the factors which influenced the variability at the time. In the present study it has been shown that not only the external stimulus pattern influences variability but also the internal stimulus pattern and the goal which is functioning at the time. Certain results from the present study also tend to show that there is a direct relation between time and variability in that the length of the experimental period influences greatly the pattern of the response.

Further, this study throws some doubt on the findings of Bryan and Harter (61 and 62) who thought that the curve of performance was determined by the degree of effort. They explained plateaus by saying that in learning to do things we ordinarily only learn to do them well enough to get along. This is the first plateau of efficiency, but an expert must go beyond this and by an extra effort ascend to a higher level of efficiency. Our results would indicate that degree of effort does not effect appreciably the level of the curve of performance.

BIBLIOGRAPHY

1. Allen, F. — The Secretory Activity of the Parotoid Gland, Quart. Jl. Exp. Physiology, 1929, 19, 337-362.

2. Allen, F. — The Unitary Behavior of the Nervous System, Canadian Jl. of Research, 1931, 4, 92-109.

3. Allen, F. — The Neural Oscillatory Effect, Quart. Jl. Exp. Physiology, 1929, 19, 363-375.

4. Allen, F. and O'Donoghue — The Post-contraction Proprioceptive Reflex: Its Augmentation and Inhibition, Quart. Jl. Exp. Physiology, 1928, 18, 199-241.

5. Amar, J. — Effects physiologiques du travail et degré de travail, C.r. acad. d. sci., 1913, 157, 646-649.

6. Bair, J. H. — The Practice Curve, Psychol. Rev., Mon., 1902, 19.

7. Bartley, S. H. and Newman, E. B. — Studies in Cerebral Action Currents: The Sensory Motor Areas. Submitted to Amer. Jl. Physiology.

8. Bills, A. G. — Blocking: A New Principle of Mental Fatigue, Amer. Jl. Psychol., 1931, 43, 230-246.

9. Bonser, F. G. — A Study of the Relations between Mental Activity and the Circulation of the Blood, Psychol. Rev. 10, 1903, 120-138.

10. Book, W. F. — The Psychology of Skill, 1925, 2nd Edition.

11. Book, W. F. and Norvell, L. — The Will to Learn, Ped. Sem., 1922, 29, 305-362.

12. Cannon, W. B. Bodily Changes in Pain, Hunger, Fear, and Rage: an Account of Recent Researches into the Function of Emotional Excitement, 1915, New York.

13. Cannon, W. B. and Washburn, A. L. An Explanation of Hunger, Amer. Jl. Physiol., 1912, 29, 441-454.

14. Carlson, A. J. The Control of Hunger in Health and Disease, 1916, Chicago.

15. Cattell, J. McK. Psychology in America, 1929, Sci. Press.

16. Davis, K. B. Periodicity of Sex Desire, Amer. Jl. Obstet. and Gynecol., 1927.

17. Farmer, E. Parallelism in Curves of Motor Performance, Brit. Jl. Psychol. 1927, 17, 335-342.

18. Féré, C. L'Influence du rhythme sure le travail, L'Année Psychol., 1902, 8, 49-105.

19. Forbes, A. and Rice, L. H. Fatigue in Peripheral Nerve, Amer. Jl. Psychol., 1929, 90 119-145.

20. Galloway, C. E. The Effect of Stimuli upon the Length of Traube-Hering Waves, Amer. Jl. Psychol., 1904, 15, 499-512.

21. Griffiths, C. H. and Gordon, E. I. The Relation between the Traube-Hering and Attention Rhythms. Jl. Exp. Psychol., 1924, 7, 117.

22. Hartmann, G. W. Initial Performance as a Basis for Predicting Ultimate Achievement, Sch. & Soc., 1929, 29, 495-496.

23. Hersey, R. B. Periodic Emotional Changes in Male Workers, Pers. Jl., 1929, 7, 459, 464.

24. Isaacs, E. The Nature of the Rhythm Experience, Psychol. Rev., 1920, 27, 270-297.

25. James, H. E. O. Regularity and Rhythmicalness. Brit. Jl. Psychol., 1926, 17, 1-9.

26. Jasper, H. and Perkins, F. T. Chronaxie Measurement by the Constant Process. Unpublished manuscript, University of Iowa.

27. Kinder, E. F. A Study of the Nest-building of the Albino Rat, Jl. Exp. Zool., 1927, 47, 117-163.

28. Lashley, K. S. Reflex Secretion of the Human Parotoid Gland, Jl. Exp. Psychol., 1916, 1, 461-494.

29. Lennes, N. J. and Fee, I. B. Variability of Individual Performance, Sch. & Soc., 1929, 29, 264-268.

30. Link, H. C. A Practical Study in Industrial Fatigue, Jl. Ind. Hyg., 1919, 1, 233-238.

31. McDougall, Wm. The Relation of Auditory Rhythm to Nervous Discharge, Psychol. Rev., 1902, 9, 460-480.

32. Miner, J. B., Motor, Visual and Applied Rhythms, Psychol. Rev. Monog., 5, No. 21.

33. Muscio, B. Fluctuations in Mental Efficiency, Brit. Jl. Psychol., 1920, 10, 317-344.

34. Nakamura, H. Experimental Study in Reaction Time of Start for Running Race, Jap. Jl. Psychol., 1928, 3, 231-262.

35. Pankratz, H. An Experimental Study of the Development and Persistence of Skill in a Complex Motor Performance. Master's Thesis, University of Kansas.

36. Patterson, T. L. The Variations in the Hunger Contractions of the Empty Stomach with Age, Amer. Jl. Physiol., 1914, 33, 423-430.

37. Perkins, F. T. A Further Study of Configurational Learning in the Goldfish. To appear in _Jl. Exp. Psychol._, 1931, 14.

38. Perkins, F. T. Symmetry in Visual Recall. To appear in _Amer. Jl. Psychol._, 1932, 44.

39. Philippe, J. Contribution á la psychologie de nos mouvements, _Rev. Phil._, 1919, 88, 78-103.

40. Pillsbury, W. B. Attention Waves as a Means of Measuring Fatigue, _Amer. Jl. Psychol._, 1903, 14, 277-288.

41. Reed, H. B. Fatigue and Work Curve from a 10-Hour Day in Addition, _Jl. Ed. Psychol._, 1929, 15, 389-392.

42. Richter, C. P. Animal Behavior and Internal Drives, _Quart. Rev. Biol._, 1927, 2, No. 3, 307-343.

43. Richter, C. P. Action Currents from the Stomach, _Amer. Jl. Physiol._, 1923-24, 67, 612-633.

44. Robinson, E. S. and Heron, W. T. The Warming-up Effect. _Jl. Exp. Psychol._, 1924, 7, 81-87.

45. Roff, M. A Study in the Learning of a Complex Motor Performance. Master's Thesis, University of Kansas.

46. Scripture, E. W. Observations on Rhythmic Action. _Science_, 1899, 10, 185-187.

47. Seashore, C. E. Motor Ability, Reaction Time, Rhythm and the Time Sense. _University of Iowa Studies in Psychol._, 1899, 2, 64-84.

48. Slaughter, J. W. The Fluctuation of Attention in Some of their Physiological Relations. _Amer. Jl. Psychol._, 1901, 12, 313.

49.	Slonaker, J. R.	The Effect of Copulation, Pregnancy, Pseudo-pregnancy and Lactation on the Voluntary Activity and Food Consumption of the Albino Rat, Amer. Jl. Physiol., 1925, 71, 362-395.
50.	Slonaker, J. R.	Long Fluctuations in Voluntary Activity in the Albino Rat, Amer. Jl. Physiol., 1926, 77, 503-509.
51.	Snoddy, G. S.	An Experimental Analysis of a Case of Trial and Error Learning in the Human Subject, Psychol. Mon., 1920, 20, No. 124.
52.	Spearman, C.	G and After: A School to End Schools, Psychologies of 1930, 358-359. Clark University, Worcester, Mass.
53.	Thorndike, E. L.	Educational Psychology, Vol. II.
54.	Travis, L. E. and Hunter, T.	Muscular Rhythms and Action Currents, Amer. Jl. Physiol., 1927, 81, 355-359.
55.	Wada, T.	An Experimental Study of Hunger in its Relation to Activity, Arch. of Psychol., 57.
56.	Waller and DeDecker	Measurements of the Energy Output of 'Heavy Workers' (Dock Laborers), Rep. Brit. Ass. Adv. Sci., 1919, 310-312.
57.	Wang, G. H.	The Relation between 'Spontaneous' Activity and Oestrous Cycle in the White Rat, 1923, Comp. Psychol. Mon., 2, No. 6.
58.	Wheeler, R. H.	Periodicity in Performance, Science of Psychology, 1929, Crowell.

59. Wulf, F. — vi. Ueber die Veranderung von Vorstellungen (Gedächtnis und Gestalt) Koffka, K., Berträge zur Psychologie der Gestalt, Psych. Forsch., 1922, 1, 333-373.

60. Wyatt, S. — An Experimental Study of a Repetitive Process. Brit. Jl. Psychol. (Gen. Sect.) 1927, 17, 192-209.

61. Bryan, W. L. and Harter, Noble — Studies in the Physiology and Psychology of the Telegraphic Language, Psychol. Rev., 4, 1897, 27-53.

62. Bryan, W. L. and Harter, Noble — Studies on the Telegraphic Language: the Acquisition of a Hierarchy of Habits, Psychol. Rev., 6, 1899, 345-375.

TABLES OF DATA

Subject Blech Trial 1st.

Date Time 2 hours

1. 22	26. 22	51. 15	76. 11	101. 22	126. 19	151.	176.
2. 34	27. 25	52. 17	77. 10	102. 12	127. 17	152.	177.
3. 23	28. 26	53. 14	78. 15	103. 14	128. 12	153.	178.
4. 37	29. 24	54. 13	79. 15	104. 14	129. 16	154.	179.
5. 27	30. 16	55. 13	80. 24	105. 16	130. 13	155.	180.
6. 23	31. 20	56. 14	81. 16	106. 12	131. 16	156.	181.
7. 25	32. 25	57. 18	82. 11	107. 14	132. 12	157.	182.
8. 30	33. 20	58. 18	83. 15	108. 11	133. 14	158.	183.
9. 28	34. 15	59. 17	84. 16	109. 22	134. 14	159.	184.
10. 27	35. 31	60. 15	85. 18	110. 28	135. 14	160.	185.
11. 19	36. 20	61. 17	86. 17	111. 13	136. 11	161.	186.
12. 29	37. 26	62. 16	87. 12	112. 16	137. 19	162.	187.
13. 29	38. 20	63. 18	88. 15	113. 21	138. 14	163.	188.
14. 23	39. 17	64. 17	89. 15	114. 14	139. 14	164.	189.
15. 35	40. 24	65. 13	90. 12	115. 19	140. 12	165.	190.
16. 23	41. 19	66. 13	91. 16	116. 16	141.	166.	191.
17. 23	42. 15	67. 15	92. 14	117. 13	142.	167.	192.
18. 18	43. 18	68. 18	93. 18	118. 14	143.	168.	193.
19. 17	44. 16	69. 15	94. 18	119. 14	144.	169.	194.
20. 26	45. 18	70. 16	95. 15	120. 14	145.	170.	195.
21. 19	46. 26	71. 16	96. 24	121. 11	146.	171.	196.
22. 26	47. 17	72. 14	97. 23	122. 15	147.	172.	197.
23. 26	48. 31	73. 17	98. 14	123. 16	148.	173.	198.
24. 18	49. 19	74. 14	99. 20	124. 13	149.	174.	199.
25. 27	50. 17	75. 16	100. 17	125. 23	150.	175.	200.

Remarks:

Subject Keown Trial 1st

Date Time 2 hours

1. 25	26. 12	51. 18	76. 19	101. 13	126. 16	151.	176.
2. 24	27. 12	52. 14	77. 17	102. 8	127. 18	152.	177.
3. 28	28. 17	53. 11	78. 16	103. 13	128. 28	153.	178.
4. 26	29. 11	54. 10	79. 15	104. 16	129. 22	154.	179.
5. 22	30. 10	55. 15	80. 24	105. 20	130. 14	155.	180.
6. 19	31. 11	56. 11	81. 18	106. 128	131.	156.	181.
7. 25	32. 10	57. 13	82. 16	107. 18	132.	157.	182.
8. 23	33. 10	58. 10	83. 20	108. 17	133.	158.	183.
9. 17	34. 13	59. 17	84. 11	109. 18	134.	159.	184.
10. 26	35. 14	60. 21	85. 9	110. 20	135.	160.	185.
11. 20	36. 11	61. 36	86. 9	111. 19	136.	161.	186.
12. 28	37. 11	62. 24	87. 13	112. 18	137.	162.	187.
13. 26	38. 12	63. 25	88. 12	113. 12	138.	163.	188.
14. 21	39. 14	64. 26	89. 9	114. 12	139.	164.	189.
15. 17	40. 17	65. 23	90. 12	115. 12	140.	165.	190.
16. 19	41. 13	66. 30	91. 11	116. 11	141.	166.	191.
17. 17	42. 17	67. 23	92. 16	117. 10	142.	167.	192.
18. 18	43. 10	68. 19	93. 23	118. 11	143.	168.	193.
19. 15	44. 16	69. 20	94. 22	119. 13	144.	169.	194.
20. 14	45. 15	70. 29	95. 15	120. 23	145.	170.	195.
21. 19	46. 24	71. 29	96. 13	121. 16	146.	171.	196.
22. 19	47. 16	72. 30	97. 15	122. 14	147.	172.	197.
23. 20	48. 20	73. 17	98. 10	123. 14	148.	173.	198.
24. 13	49. 11	74. 20	99. 11	124. 15	149.	174.	199.
25. 14	50. 12	75. 23	100. 14	125. 16	150.	175.	200.

Remarks:

Sheet 1.

Subject Ruth McMillin Trial 1st

Date April 15, 1930 Time 3:30 - 4:30.

1. 137	26. 41	51. 32	76.	101.	126.	151.	176.
2. 95	27. 57	52. 23	77.	102.	127.	152.	177.
3. 114	28. 79	53. 23	78.	103.	128.	153.	178.
4. 104	29. 73	54. 35	79.	104.	129.	154.	179.
5. 110	30. 30	55. 25	80.	105.	130.	155.	180.
6. 149	31. 35	56. 27	81.	106.	131.	156.	181.
7. 95	32. 38	57. 41	82.	107.	132.	157.	182.
8. 114	33. 52	58. 39	83.	108.	133.	158.	183.
9. 83	34. 21	59. 34	84.	109.	134.	159.	184.
10. 104	35. 19	60. 19	85.	110.	135.	160.	185.
11. 149	36. 57	61. 31	86.	111.	136.	161.	186.
12. 98	37. 67	62. 28	87.	112.	137.	162.	187.
13. 70	38. 44	63. 27	88.	113.	138.	163.	188.
14. 69	39. 27	64.	89.	114.	139.	164.	189.
15. 69	40. 35	65.	90.	115.	140.	165.	190.
16. 98	41. 37	66.	91.	116.	141.	166.	191.
17. 60	42. 131	67.	92.	117.	142.	167.	192.
18. 65	43. 42	68.	93.	118.	143.	168.	193.
19. 80	44. 23	69.	94.	119.	144.	169.	194.
20. 69	45. 33	70.	95.	120.	145.	170.	195.
21. 57	46. 38	71.	96.	121.	146.	171.	196.
22. 33	47. 35	72.	97.	122.	147.	172.	197.
23. 33	48. 37	73.	98.	123.	148.	173.	198.
24. 69	49. 21	74.	99.	124.	149.	174.	199.
25. 36	50. 23	75.	100	125.	150.	175.	200.

Remarks: Reports going over is easy. Wants to scream. Thinks maze is changed and I am lieing about the maze. Thinks she should be at goal but is not. Gets mad.

Sheet 1

Subject Ruth Mullins Trial 2nd

Date April 25-1930 Time 9:30 - 10:30

1. 47	26. 10	51. 14	76. 11	✓101. 27	126. 10	151. 8	✓176. 13
2. 30	27. 16	52. 15	77. 15	102. 10	127. 12	152. 9	177. 10
3. 43	28. 10	53. 15	✓78. 13	103. 18	128. 7	153. 12	178. 8
4. 13	29. 15	54. 9	79. 15	104. 22	129. 15	154. 10	179. 13
5. 17	30. 10	55. 13	80. 12	105. 12	✓130. 115	155. 15	180. 10
6. 18	31. 25	56. 13	81. 15	106. 10	131. 33	156. 14	181. 14
7. 20	32. 13	57. 13	82. 9	107. 10	132. 9	157. 12	182. 11
8. 12	33. 24	58. 12	83. 12	108. 10	133. 14	158. 14	183. 13
9. 11	✓34. 21	59. 16	84. 8	109. 18	134. 9	159. 11	✓184. 10
10. 17	35. 20	60. 10	85. 13	110. 8	135. 11	160. 10	185. 17
11. 13	36. 12	61. 15	86. 11	111. 13	136. 6	161. 11	186. 8
12. 11	37. 19	62. 22	87. 18	112. 10	137. 10	162. 16	187. 16
13. 18	38. 16	63. 16	88. 8	113. 16	138. 10	163. 11	188. 6
14. 11	39. 25	64. 10	89. 13	114. 9	139. 10	164. 15	189. 12
15. 32	40. 15	65. 14	✓90. 12	115. 15	140. 9	165. 13	190. 9
16. 11	41. 21	66. 12	✓91. 24	116. 9	141. 17	166. 7	191. 15
17. 18	42. 20	67. 14	92. 12	117. 13	142. 10	167. 10	192. 9
18. 26	43. 14	68. 12	93. 15	118. 8	143. 14	168. 10	193. 13
19. 24	44. 22	69. 12	94. 13	119. 13	144. 9	169. 18	194. 11
20. 16	45. 17	70. 12	95. 18	120. 8	145. 14	170. 12	195. 15
21. 23	46. 12	71. 17	96. 9	121. 12	146. 17	171. 10	196. 10
22. 20	47. 27	72. 9	97. 15	122. 11	147. 15	172. 8	197. 17
23. 20	48. 13	73. 14	98. 12	123. 12	148. 12	173. 13	198. 9
24. 10	49. 19	74. 12	99. 28	124. 12	149. 13	174. 11	199. 10
25. 17	50. 12	75. 22	100. 20	125. 12	150. 16	175. 13	200. 8

Remarks:
34- Got mixed up.
78- Seemed different
90- Didn't know goal.
91- Dropped stylus
101- Lost
130- Completely lost.

176- Didn't know when she reached the end
184- Doesn't feel right.
Note: Subject had to go back to beginning when lost.

Sheet 2

Subject Ruth McMillan Trial 2nd

Date April 25-1930. Time 9:30-10:30

1. 9	26. 10	51. 61	76.	101.	126.	151.	176.
2. 24	27. 13	52. 12	77.	102.	127.	152.	177.
3. 13	28. 8	53. 10	78.	103.	128.	153.	178.
4. 9	29. 24	54. 10	79.	104.	129.	154.	179.
5. 10	30. 10	55. 17	80.	105.	130.	155.	180.
6. 9	31. 13	56. 9	81.	106.	131.	156.	181.
7. 44	32. 6	57. 15	82.	107.	132.	157.	182.
8. 10	33. 14	58.	83.	108.	133.	158.	183.
9. 12	34. 8	59.	84.	109.	134.	159.	184.
10. 7	35. 12	60.	85.	110.	135.	160.	185.
11. 16	36. 7	61.	86.	111.	136.	161.	186.
12. 10	37. 10	62.	87.	112.	137.	162.	187.
13. 10	38. 13	63.	88.	113.	138.	163.	188.
14. 8	39. 11	64.	89.	114.	139.	164.	189.
15. 10	40. 18	65.	90.	115.	140.	165.	190.
16. 8	41. 13	66.	91.	116.	141.	166.	191.
17. 9	42. 7	67.	92.	117.	142.	167.	192.
18. 7	43. 11	68.	93.	118.	143.	168.	193.
19. 10	44. 10	69.	94.	119.	144.	169.	194.
20. 14	45. 13	70.	95.	120.	145.	170.	195.
21. 10	46. 12	71.	96.	121.	146.	171.	196.
22. 12	47. 12	72.	97.	122.	147.	172.	197.
23. 9	48. 8	73.	98.	123.	148.	173.	198.
24. 12	49. 14	74.	99.	124.	149.	174.	199.
25. 25	50. 11	75.	100	125.	150.	175.	200.

Remarks:
1. Lost.
25. Retraced
51. completely lost.

Note: Subject seemed in doubt when at the end of the last part of the experiment. Reports it easier to go over.

Subject [illegible] Trial 3rd Sheet 1.

Date April 29-1930. Time 3:30-4:30.

1.21	26.16	51.34	76.9	101.11	126.8	151.8	176.8
2.10	27.13	52.28	77.9	102.24	127.10	152.25	177.7
3.18	28.14	53.10	78.16	103.7	128.9	153.7	178.22
4.8	29.9	54.9	79.11	104.8	129.8	154.13	179.8
5.10	30.10	55.13	80.11	105.8	130.6	155.7	180.6
6.8	31.13	56.13	81.10	106.10	131.8	156.10	181.7
7.15	32.8	57.9	82.8	107.11	132.8	157.9	182.8
8.10	33.7	58.10	83.8	108.12	133.8	158.9	183.7
9.11	34.9	59.7	84.11	109.10	134.9	159.6	184.9
10.12	35.14	60.8	85.14	110.8	135.12	160.13	185.8
11.7	36.14	61.9	86.11	111.9	136.6	161.7	186.12
12.12	37.10	62.9	87.12	112.10	137.7	162.7	187.8
13.11	38.11	63.11	88.11	113.7	138.7	163.8	188.8
14.9	39.10	64.10	89.12	114.11	139.18	164.8	189.8
15.14	40.8	65.8	90.14	115.9	140.8	165.6	190.9
16.8	41.9	66.11	91.8	116.9	141.9	166.7	191.9
17.12	42.8	67.11	92.17	117.12	142.8	167.7	192.8
18.9	43.8	68.12	93.7	118.8	143.10	168.8	193.6
19.18	44.9	69.8	94.10	119.8	144.10	169.9	194.8
20.38	45.8	70.27	95.8	120.11	145.8	170.8	195.11
21.12	46.23	71.10	96.15	121.11	146.9	171.7	196.8
22.11	47.9	72.9	97.8	122.9	147.9	172.7	197.10
23.26	48.8	73.8	98.11	123.7	148.8	173.6	198.10
24.12	49.10	74.12	99.9	124.9	149.11	174.7	199.8
25.9	50.12	75.11	100.9	125.8	150.10	175.9	200.14.

Remarks:

20- Lost
23- Lost
46- Lost
51- Everything seems wrong
70- Lost

90- Lost
102- Lost
139- Lost
143- Lost
152- Lost

Sheet 2

Subject [illegible] Trial 3rd

Date April 29-1930 Time 3:30-4:30

1. 10	26. 6	51. 8	76. 7	101. 8	126. 9	151.	176.
2. 12	27. 7	52. 7	77. 6	102. 8	127. 8	152.	177.
3. 7	28. 8	53. 7	78. 6	103. 8	128. 7	153.	178.
4. 8	29. 8	54. 8	79. 9	104. 10	129. 7	154.	179.
5. 8	30. 8	55. 6	80. 10	✓105. 23	130. 10	155.	180.
6. 9	31. 12	56. 7	81. 7	106. 8	131. 11	156.	181.
7. 8	32. 7	57. 13	✓82. 18	107. 8	132. 8	157.	182.
8. 9	33. 8	58. 5	83. 8	108. 18	133. 9	158.	183.
9. 8	✓34. 15	59. 7	84. 9	109. 6	134. 7	159.	184.
10. 7	35. 12	60. 7	85. 8	110. 7	135. 10	160.	185.
11. 6	36. 10	61. 9	86. 7	111. 7	136. 6	161.	186.
12. 9	37. 10	62. 7	87. 11	112. 11	137. 8	162.	187.
13. 7	38. 10	63. 8	88. 9	113. 9	138. 7	163.	188.
14. 8	39. 12	64. 10	89. 8	114. 10	139. 7	164.	189.
15. 14	40. 7	65. 10	✓90. 7	115. 7	✓140. 17	165.	190.
16. 8	41. 8	66. 6	91. 9	116. 7	141. 8	166.	191.
17. 12	42. 7	67. 7	92. 5	117. 8	142. 6	167.	192.
18. 8	43. 10	68. 6	93. 6	✓118. 40	143. 10	168.	193.
19. 9	44. 9	69. 7	94. 10	119. 11	144. 13	169.	194.
20. 11	45. 7	70. 8	95. 10	120. 7	145. 9	170.	195.
21. 7	46. 9	71. 6	96. 12	121. 12	146.	171.	196.
22. 7	47. 9	72. 5	97. 8	122. 11	147.	172.	197.
✓23. 8	✓48. 17	✓73. 7	98. 5	123. 10	148.	173.	198.
24. 10	49. 11	✓74. 8	✓99. 10	124. 8	149.	174.	199.
25. 10	50. 16	75. 7	100. 6	125. 8	150.	175.	200.

Remarks:
23-Rest
34-Rest
48-Rest
73-Rest
74-Rest
82-Rest
90-Rest
99-Rest
105-Rest
140-Rest

Note: Very tired - hand went to sleep, couldn't remember maze pattern.

Sheet 1.

Subject Millie Trial 4th

Date May 7 - 1930 Time 9:30 - 10:30.

1. 9	26. 10	51. 8	76. 7	101. 7	126. 11	151. 8	176. 6
2. 6	27. 9	52. 8	77. 8	102. 9	127. 5	152. 8	177. 6
3. 7	28. 10	53. 8	78. 6	103. 7	128. 7	153. 7	178. 9
4. 9	29. 9	54. 6	79. 6	104. 6	129. 7	154. 10	179. 7
5. 6	30. 8	55. 7	80. 8	105. 8	130. 7	155. 10	180. 8
6. 10	31. 9	56. 18	81. 10	106. 8	131. 9	156. 7	181. 5
7. 10	32. 10	57. 8	82. 10	107. 10	132. 8	157. 8	182. 8
8. 8	33. 11	58. 7	83. 6	108. 7	133. 9	158. 8	183. 7
9. 7	34. 8	59. 8	84. 7	109. 8	134. 7	159. 9	184. 6
10. 7	35. 13	60. 8	85. 7	110. 6	135. 8	160. 6	185. 9
11. 7	36. 10	61. 15	86. 7	111. 9	136. 6	161. 7	186. 8
12. 7	37. 8	62. 12	87. 8	112. 10	137. 8	162. 6	187. 7
13. 8	38. 6	63. 10	88. 7	113. 8	138. 6	163. 9	188. 9
14. 8	39. 9	64. 8	89. 8	114. 8	139. 8	164. 7	189. 8
15. 8	40. 9	65. 6	90. 7	115. 9	140. 9	165. 8	190. 7
16. 9	41. 12	66. 6	91. 6	116. 7	141. 10	166. 7	191. 11
17. 8	42. 9	67. 9	92. 7	117. 9	142. 10	167. 5	192. 8
18. 9	43. 9	68. 7	93. 6	118. 8	143. 10	168. 7	193. 11
19. 10	44. 7	69. 7	94. 8	119. 7	144. 7	169. 10	194. 10
20. 11	45. 7	70. 7	95. 8	120. 8	145. 9	170. 8	195. 6
21. 12	46. 6	71. 9	96. 6	121. 5	146. 7	171. 10	196. 12
22. 11	47. 9	72. 6	97. 14	122. 6	147. 8	172. 7	197. 8
23. 12	48. 8	73. 13	98. 10	123. 7	148. 6	173. 6	198. 8
24. 11	49. 11	74. 6	99. 7	124. 18	149. 7	174. 7	199. 6
25. 8	50. 7	75. 5	100. 7	125. 9	150. 10	175. 7	200. 7

Remarks: Easier to go over.
56 - lost
124 - lost

No. # 1.

Sheet 2.

Subject Miller Trial 4th

Date May 7-1930 Time 9:30-10:30.

1.6	26.6	51.15	76.6	101.6	126.7	151.6	176.6
2.10	27.9	52.10	77.7	102.6	127.9	152.8	177.6
3.8	28.11	53.8	78.6	103.10	128.7	153.7	178.8
4.10	29.8	54.5	79.8	104.8	129.8	154.8	179.8
5.7	30.5	55.7	80.8	105.6	130.10	155.7	180.6
6.9	31.6	56.7	81.9	106.7	131.10	156.9	181.6
7.8	32.10	57.8	✓82.13	107.6	132.11	157.6	✓182.9
8.8	33.7	58.11	83.9	108.7	133.7	158.6	183.8
9.6	34.8	59.9	84.8	109.6	134.7	159.7	184.6
10.7	35.7	60.6	85.5	110.6	135.6	160.9	185.8
11.8	36.6	61.6	✓86.13	111.8	136.6	161.8	186.8
12.7	37.8	62.6	87.7	112.8	137.8	162.7	✓187.1
13.12	38.12	63.7	88.7	113.6	138.6	163.9	188.7
14.6	39.6	64.9	89.8	114.8	139.8	164.6	189.6
15.7	40.6	65.11	90.8	115.5	140.5	✓165.10	190.
16.6	41.8	66.7	91.8	116.5	141.5	166.6	191.
17.8	42.8	67.6	92.6	117.8	✓142.13	167.6	192.
18.7	✓43.8	68.7	93.7	118.6	143.6	168.9	193.
19.8	44.5	69.7	94.12	119.8	144.8	169.7	194.
20.5	45.6	70.8	95.7	✓120.9	145.5	170.6	195.
21.5	46.8	71.8	96.12	121.6	146.6	171.7	196.
22.8	47.7	72.8	97.7	✓122.16	147.9	172.7	197.
23.10	✓48.19	73.8	98.6	123.6	148.6	173.7	198.
24.7	49.8	74.6	99.8	124.7	149.6	174.9	199.
25.12	50.6	75.7	100.7	125.6	150.6	175.8	200.

Remarks:
43 - Post 122 - Post
48 - Post 142 - Post
82 - Post 165 - Post
[illegible]

Sheet 1

Subject Millin　　Trial 5th

Date May 14, 1930.　　Time 9:30-10:30.

1. 8	26. 7	51. 9	76. 8	101. 6	126. 9	151. 10	176. 5
2. 7	27. 14	52. 6	77. 10	102. 8	127. 6	152. 7	177. 5
3. 11	28. 10	53. 7	78. 11	103. 11	128. 9	153. 7	178. 6
4. 7	29. 7	54. 8	79. 10	104. 7	129. 6	154. 6	179. 6
5. 6	30. 9	55. 5	80. 7	105. 7	130. 7	155. 6	180. 10
6. 7	31. 8	56. 8	81. 7	106. 5	131. 7	156. 6	181. 8
7. 8	32. 10	57. 7	82. 7	107. 7	132. 10	157. 6	182. 7
8. 6	33. 7	58. 7	83. 5	108. 7	133. 6	158. 9	183. 6
9. 7	34. 15	59. 8	84. 11	109. 7	134. 11	159. 7	184. 9
10. 6	35. 6	60. 17	85. 6	110. 8	135. 6	160. 6	185. 8
11. 7	36. 6	61. 7	86. 7	111. 6	136. 7	161. 7	186. 8
12. 9	37. 5	62. 8	87. 5	112. 5	137. 7	162. 9	187. 6
13. 6	38. 6	63. 8	88. 6	113. 7	138. 8	163. 7	188. 10
14. 11	39. 6	64. 8	89. 5	114. 7	139. 10	164. 6	189. 9
15. 7	40. 6	65. 6	90. 6	115. 8	140. 7	165. 6	190. 8
16. 10	41. 9	66. 7	91. 7	116. 7	141. 7	166. 7	191. 8
17. 8	42. 7	67. 6	92. 6	117. 6	142. 12	167. 6	192. 6
18. 8	43. 9	68. 16	93. 6	118. 8	143. 5	168. 7	193. 7
19. 5	44. 7	69. 8	94. 6	119. 6	144. 5	169. 6	194. 9
20. 7	45. 7	70. 12	95. 10	120. 6	145. 5	170. 6	195. 7
21. 7	46. 11	71. 12	96. 7	121. 7	146. 5	171. 6	196. 14
22. 13	47. 8	72. 9	97. 8	122. 9	147. 5	172. 5	197. 10
23. 9	48. 6	73. 7	98. 7	123. 8	148. 6	173. 5	198. 10
24. 15	49. 6	74. 7	99. 8	124. 7	149. 5	174. 6	199. 8
25. 7	50. 7	75. 11	100. 10	125. 7	150. 9	175. 21	200. 8

Remarks: Great disturbance in class room.
68-More disturbance.
196 to 199 - seems unfamiliar with the maze.
Maze seems uncorrected.

Sheet 2

Subject Miller | Trial 5th

Date May 14 - 1932. | Time 9:30-10:30.

1.5	✓26.11	51.8	76.7	101.6	126.8	151.9	176.7
2.10	✓27.10	52.9	77.10	102.5	127.6	152.6	177.7
3.9	✓28.25	53.11	78.10	103.8	128.5	153.6	178.4
✓4.59	29.7	54.8	79.7	104.6	129.7	154.5	179.7
5.13	30.6	55.8	80.6	105.11	130.5	155.9	180.7
6.6	31.8	56.13	81.7	106.7	131.8	156.6	181.6
7.6	32.6	57.9	82.6	107.6	132.9	157.5	182.5
8.6	33.8	58.9	83.6	108.8	133.6	158.4	183.7
9.5	34.4	59.11	84.7	109.6	134.7	159.6	184.5
10.13	35.5	60.6	85.6	110.7	135.5	160.6	185.6
11.12	36.9	61.10	86.5	111.6	136.7	161.6	186.6
✓12.25	37.7	62.7	87.5	112.8	137.6	162.8	187.6
13.13	38.6	63.11	88.6	113.8	138.9	163.6	188.6
14.5	39.8	64.7	89.6	114.7	139.5	164.5	189.10
15.7	40.6	65.10	90.8	115.8	140.7	165.5	190.9
16.9	41.10	66.10	91.8	116.7	141.8	166.5	191.8
17.6	42.7	67.10	92.6	117.8	142.7	167.5	192.9
18.9	43.9	68.10	93.8	118.11	143.6	168.6	193.7
19.8	44.8	69.9	94.8	119.8	144.8	169.6	194.8
20.6	45.9	70.10	95.8	120.8	145.8	170.5	195.7
21.10	46.6	71.7	96.8	121.8	146.8	171.6	196.5
22.5	47.6	72.5	97.6	122.8	147.5	172.5	197.9
23.9	48.7	73.5	98.7	123.8	148.6	173.7	198.9
✓24.21	49.7	74.8	99.9	124.7	149.6	174.6	199.7
✓25.12	50.8	75.6	100.10	✓125.14	150.5	175.5	200.7

Remarks:
4 - Entirely lost
12 - Lost
24 & 28 - can't find self.
125 - Lost.

Sheet 3

Subject Mullin Trial 5th

Date May 14 - 1930. Time 9:30 - 10:30.

1. 8	26. 12	51. 7	76.	101.	126.	151.	176.
2. 26	27. 7	52. 5	77.	102.	127.	152.	177.
3. 6	28. 7	53. 6	78.	103.	128.	153.	178.
4. 9	29. 12	54. 7	79.	104.	129.	154.	179.
5. 5	30. 7	55. 8	80.	105.	130.	155.	180.
6. 5	31. 7	56. 8	81.	106.	131.	156.	181.
7. 7	32. 17	57. 7	82.	107.	132.	157.	182.
8. 6	33. 8	58. 14	83.	108.	133.	158.	183.
9. 6	34. 6	59. 5	84.	109.	134.	159.	184.
10. 6	35. 7	60. 5	85.	110.	135.	160.	185.
11. 6	36. 6	61. 4	86.	111.	136.	161.	186.
12. 6	37. 6	62. 4	87.	112.	137.	162.	187.
13. 6	38. 6	63. 5	88.	113.	138.	163.	188.
14. 6	39. 7	64. 7	89.	114.	139.	164.	189.
15. 6	40. 8	65. 5	90.	115.	140.	165.	190.
16. 5	41. 10	66.	91.	116.	141.	166.	191.
17. 7	42. 6	67.	92.	117.	142.	167.	192.
18. 7	43. 21	68.	93.	118.	143.	168.	193.
19. 9	44. 6	69.	94.	119.	144.	169.	194.
20. 5	45. 6	70.	95.	120.	145.	170.	195.
21. 8	46. 7	71.	96.	121.	146.	171.	196.
22. 6	47. 6	72.	97.	122.	147.	172.	197.
23. 11	48. 7	73.	98.	123.	148.	173.	198.
24. 18	49. 6	74.	99.	124.	149.	174.	199.
25. 10	50. 8	75.	100	125.	150.	175.	200.

Remarks:

Square Tracing. Sheet 1.

Subject Miss Kershner Trial 1st

Date Jan. 8-1931 Time 2:30-3:30.

1. 10	26. 5	51. 5	76. 6	101. 5	126. 5	151. 5	176. 6
2. 7	27. 6	52. 5	77. 5	102. 7	127. 6	152. 5	177. 7
3. 6	28. 5	53. 6	78. 6	103. 6	128. 5	153. 5	178. 7
4. 6	29. 6	54. 10	79. 5	104. 9	129. 5	154. 8	179. 6
5. 9	30. 5	55. 7	80. 5	105. 5	130. 6	155. 5	180. 6
6. 8	31. 7	56. 5	81. 6	106. 6	131. 7	156. 6	181. 5
7. 7	32. 5	57. 6	82. 7	107. 6	132. 5	157. 5	182. 6
8. 8	33. 6	58. 5	83. 5	108. 5	133. 5	158. 5	183. 6
9. 6	34. 5	59. 8	84. 7	109. 6	134. 6	159. 10	184. 5
10. 6	35. 8	60. 6	85. 6	110. 5	135. 5	160. 7	185. 5
11. 5	36. 5	61. 6	86. 7	111. 5	136. 5	161. 5	186. 5
12. 6	37. 6	62. 5	87. 5	112. 5	137. 7	162. 6	187. 6
13. 8	38. 5	63. 7	88. 6	113. 6	138. 5	163. 5	188. 5
14. 6	39. 5	64. 7	89. 8	114. 7	139. 6	164. 6	189. 5
15. 6	40. 5	65. 6	90. 7	115. 6	140. 5	165. 5	190. 6
16. 6	41. 8	66. 5	91. 7	116. 6	141. 6	166. 5	191. 7
17. 5	42. 5	67. 7	92. 7	117. 5	142. 5	167. 7	192. 6
18. 5	43. 5	68. 6	93. 5	118. 6	143. 5	168. 7	193. 6
19. 5	44. 7	69. 5	94. 5	119. 5	144. 5	169. 5	194. 5
20. 5	45. 6	70. 5	95. 7	120. 5	145. 5	170. 6	195. 5
21. 7	46. 6	71. 7	96. 6	121. 5	146. 7	171. 5	196. 6
22. 6	47. 6	72. 8	97. 6	122. 5	147. 5	172. 5	197. 5
23. 5	48. 5	73. 7	98. 5	123. 4	148. 6	173. 7	198. 5
24. 5	49. 5	74. 6	99. 6	124. 6	149. 6	174. 6	199. 7
25. 6	50. 5	75. 8	100 5	125. 5	150. 6	175. 5	200. 5

Remarks:

Square Tracing. Sheet 2.

Subject Miss Kershner Trial 1st

Date Jan. 8-1931 Time 2:30-3:30

1. 6	26. 5	51. 5	76. 5	101. 5	126. 4	151. 4	176. 3
2. 5	27. 5	52. 7	77. 4	102. 4	127. 5	152. 4	177. 5
3. 6	28. 6	53. 5	78. 4	103. 5	128. 4	153. 5	178. 4
4. 5	29. 5	54. 4	79. 5	104. 6	129. 4	154. 5	179. 5
5. 7	30. 5	55. 9	80. 4	105. 5	130. 4	155. 5	180. 5
6. 9	31. 6	56. 6	81. 7	106. 5	131. 4	156. 5	181. 6
7. 6	32. 5	57. 5	82. 4	107. 6	132. 5	157. 6	182. 5
8. 5	33. 8	58. 10	83. 4	108. 4	133. 5	158. 5	183. 4
9. 5	34. 5	59. 4	84. 5	109. 4	134. 4	159. 6	184. 4
10. 5	35. 5	60. 6	85. 5	110. 5	135. 4	160. 5	185. 4
11. 6	36. 5	61. 4	86. 6	111. 4	136. 5	161. 4	186. 5
12. 6	37. 5	62. 5	87. 5	112. 4	137. 4	162. 4	187. 4
13. 5	38. 7	63. 6	88. 5	113. 4	138. 5	163. 8	188. 5
14. 5	39. 6	64. 5	89. 4	114. 4	139. 5	164. 6	189. 4
15. 7	40. 4	65. 4	90. 7	115. 10	140. 6	165. 4	190. 5
16. 6	41. 5	66. 5	91. 6	116. 6	141. 5	166. 4	191. 4
17. 5	42. 4	67. 4	92. 5	117. 5	142. 4	167. 4	192. 5
18. 5	43. 4	68. 4	93. 5	118. 4	143. 4	168. 5	193. 4
19. 6	44. 7	69. 4	94. 4	119. 4	144. 4	169. 5	194. 5
20. 5	45. 5	70. 5	95. 5	120. 5	145. 4	170. 5	195. 6
21. 6	46. 5	71. 4	96. 6	121. 4	146. 4	171. 5	196. 5
22. 5	47. 5	72. 9	97. 5	122. 4	147. 5	172. 5	197. 4
23. 7	48. 6	73. 4	98. 4	123. 4	148. 4	173. 4	198. 4
24. 6	49. 4	74. 7	99. 4	124. 4	149. 6	174. 4	199. 4
25. 5	50. 3	75. 4	100 4	125. 4	150. 5	175. 4	200. 5

Remarks:

Sheet 1.

Subject Miss [illegible] Trial 2nd

Date Jan 9, 1931 Time 2:30.

1.5	26.5	51.5	76.4	101.5	126.4	151.3	176.3
2.5	27.4	52.4	77.6	102.4	127.3	152.3	177.4
3.4	28.4	53.4	78.5	103.4	128.3	153.5	178.4
4.4	29.5	54.5	79.4	104.4	129.3	154.3	179.5
5.6	30.4	55.4	80.7	105.3	130.4	155.4	180.4
6.4	31.5	56.4	81.4	106.3	131.3	156.3	181.4
7.4	32.4	57.4	82.4	107.3	132.4	157.5	182.3
8.4	33.4	58.4	83.4	108.4	133.3	158.3	183.4
9.4	34.4	59.5	84.5	109.3	134.4	159.5	184.3
10.4	35.4	60.4	85.4	110.3	135.7	160.3	185.5
11.4	36.4	61.5	86.3	111.3	136.3	161.4	186.4
12.5	37.5	62.5	87.4	112.3	137.3	162.4	187.4
13.4	38.4	63.4	88.4	113.3	138.3	163.4	188.5
14.5	39.4	64.4	89.4	114.5	139.3	164.3	189.4
15.5	40.4	65.3	90.4	115.3	140.8	165.3	190.4
16.4	41.4	66.4	91.4	116.4	141.4	166.4	191.4
17.4	42.5	67.3	92.5	117.3	142.3	167.4	192.4
18.5	43.3	68.5	93.4	118.3	143.9	168.4	193.3
19.4	44.4	69.3	94.3	119.5	144.5	169.4	194.4
20.4	45.6	70.3	95.3	120.3	145.5	170.4	195.8
21.4	46.4	71.4	96.5	121.3	146.3	171.3	196.4
22.4	47.4	72.4	97.5	122.3	147.5	172.4	197.8
23.4	48.4	73.5	98.3	123.4	148.3	173.3	198.4
24.4	49.3	74.5	99.4	124.4	149.4	174.4	199.5
25.5	50.4	75.4	100.4	125.4	150.4	175.6	200.4

Remarks:

Sheet 2.

Subject Miss Henderson Trial 2nd

Date Jan 9, 1931 Time 2:30.

1. 3	26. 3	51. 3	76. 4	101. 4	126. 3	151. 4	176. 4
2. 5	27. 3	52. 4	77. 6	102. 3	127. 3	152. 5	177. 4
3. 3	28. 3	53. 3	78. 4	103. 5	128. 3	153. 4	178. 4
4. 3	29. 4	54. 3	79. 5	104. 5	129. 3	154. 3	179. 4
5. 5	30. 4	55. 3	80. 6	105. 4	130. 4	155. 3	180. 4
6. 4	31. 3	56. 4	81. 3	106. 3	131. 4	156. 3	181. 4
7. 3	32. 3	57. 4	82. 3	107. 5	132. 5	157. 3	182. 3
8. 3	33. 6	58. 4	83. 3	108. 3	133. 3	158. 3	183. 3
9. 6	34. 3	59. 4	84. 5	109. 3	134. 5	159. 5	184. 3
10. 3	35. 4	60. 3	85. 3	110. 5	135. 3	160. 5	185. 5
11. 5	36. 4	61. 8	86. 3	111. 4	136. 3	161. 4	186. 3
12. 3	37. 3	62. 6	87. 3	112. 5	137. 3	162. 3	187. 4
13. 4	38. 3	63. 4	88. 3	113. 4	138. 5	163. 4	188. 3
14. 4	39. 3	64. 4	89. 5	114. 3	139. 3	164. 4	189. 3
15. 6	40. 3	65. 4	90. 4	115. 3	140. 3	165. 4	190. 4
16. 5	41. 3	66. 4	91. 4	116. 2	141. 3	166. 4	191. 4
17. 5	42. 3	67. 3	92. 3	117. 3	142. 4	167. 3	192. 4
18. 3	43. 4	68. 3	93. 4	118. 3	143. 4	168. 4	193. 3
19. 4	44. 3	69. 5	94. 4	119. 3	144. 4	169. 3	194. 3
20. 3	45. 4	70. 6	95. 5	120. 3	145. 4	170. 5	195. 3
21. 4	46. 3	71. 4	96. 3	121. 3	146. 4	171. 3	196. 9
22. 4	47. 7	72. 4	97. 3	122. 4	147. 4	172. 5	197. 3
23. 4	48. 4	73. 3	98. 3	123. 3	148. 4	173. 4	198. 5
24. 4	49. 3	74. 3	99. 3	124. 3	149. 5	174. 3	199. 4
25. 3	50. 3	75. 4	100. 4	125. 3	150. 5	175. 3	200. 4

Remarks:

Sheet 3.

Subject Miss Kershner Trial 2nd

Date Jan. 9, 1931 Time 2:30.

1. 4	26. 3	51. 4	76. 4	101. 3	126.	151.	176.
2. 5	27. 3	52. 3	77. 5	102. 4	127.	152.	177.
3. 4	28. 4	53. 6	78. 3	103. 3	128.	153.	178.
4. 4	29. 5	54. 5	79. 5	104. 5	129.	154.	179.
5. 5	30. 4	55. 6	80. 3	105. 3	130.	155.	180.
6. 4	31. 5	56. 5	81. 5	106. 6	131.	156.	181.
7. 3	32. 3	57. 4	82. 4	107. 3	132.	157.	182.
8. 4	33. 6	58. 3	83. 3	108. 4	133.	158.	183.
9. 4	34. 3	59. 4	84. 4	109. 3	134.	159.	184.
10. 4	35. 3	60. 5	85. 3	110. 3	135.	160.	185.
11. 4	36. 5	61. 4	86. 5	111. 5	136.	161.	186.
12. 3	37. 6	62. 4	87. 4	112. 3	137.	162.	187.
13. 3	38. 7	63. 4	88. 4	113. 5	138.	163.	188.
14. 3	39. 4	64. 6	89. 3	114. 3	139.	164.	189.
15. 3	40. 5	65. 3	90. 3	115. 3	140.	165.	190.
16. 3	41. 6	66. 4	91. 6	116.	141.	166.	191.
17. 3	42. 4	67. 3	92. 3	117.	142.	167.	192.
18. 3	43. 4	68. 4	93. 4	118.	143.	168.	193.
19. 5	44. 3	69. 3	94. 3	119.	144.	169.	194.
20. 4	45. 3	70. 3	95. 6	120.	145.	170.	195.
21. 4	46. 5	71. 4	96. 3	121.	146.	171.	196.
22. 5	47. 3	72. 3	97. 4	122.	147.	172.	197.
23. 3	48. 4	73. 5	98. 3	123.	148.	173.	198.
24. 6	49. 5	74. 5	99. 5	124.	149.	174.	199.
25. 3	50. 4	75. 5	100. 4	125.	150.	175.	200.

Remarks:

Sheet 1.

Subject Miss Kershner Trial 3rd

Date Jan 14-1931 Time 2:45

1. 8	26. 5	51. 6	76. 7	101. 5	126. 6	151. 7	176.
2. 6	27. 5	52. 7	77. 7	102. 6	127. 5	152. 6	177.
3. 6	28. 6	53. 5	78. 7	103. 7	128. 7	153. 5	178.
4. 5	29. 5	54. 6	79. 6	104. 7	129. 5	154. 6	179.
5. 5	30. 6	55. 6	80. 5	105. 8	130. 6	155. 5	180.
6. 6	31. 6	56. 6	81. 7	106. 6	131. 5	156.	181.
7. 6	32. 5	57. 5	82. 8	107. 5	132. 6	157.	182.
8. 5	33. 5	58. 7	83. 7	108. 7	133. 6	158.	183.
9. 6	34. 6	59. 8	84. 10	109. 6	134. 5	159.	184.
10. 5	35. 6	60. 6	85. 9	110. 6	135. 8	160.	185.
11. 5	36. 6	61. 7	86. 8	111. 6	136. 6	161.	186.
12. 6	37. 6	62. 6	87. 7	112. 7	137. 5	162.	187.
13. 6	38. 7	63. 7	88. 8	113. 6	138. 6	163.	188.
14. 7	39. 6	64. 6	89. 7	114. 7	139. 5	164.	189.
15. 6	40. 6	65. 8	90. 8	115. 6	140. 8	165.	190.
16. 5	41. 6	66. 6	91. 7	116. 5	141. 6	166.	191.
17. 6	42. 7	67. 7	92. 8	117. 6	142. 6	167.	192.
18. 5	43. 6	68. 6	93. 6	118. 7	143. 6	168.	193.
19. 6	44. 6	69. 8	94. 6	119. 6	144. 5	169.	194.
20. 5	45. 7	70. 5	95. 5	120. 7	145. 5	170.	195.
21. 6	46. 6	71. 8	96. 6	121. 6	146. 5	171.	196.
22. 7	47. 6	72. 8	97. 6	122. 5	147. 5	172.	197.
23. 6	48. 6	73. 7	98. 7	123. 6	148. 6	173.	198.
24. 5	49. 6	74. 8	99. 8	124. 6	149. 7	174.	199.
25. 5	50. 6	75. 6	100. 5	125. 5	150. 7	175.	200.

Remarks:

Time out at 150 & 155. Broke Down.

Sheet 1.

Subject Miss Kershner Trial 4th

Date Jan. 16, 1931 Time 2:45.

1. 6	26. 8	51. 5	76. 6	101. 6	126. 5	151. 7	176. 8
2. 5	27. 8	52. 5	77. 7	102. 7	127. 9	152. 8	177. 8
3. 5	28. 5	53. 5	78. 6	103. 7	128. 8	153. 6	178. 5
4. 5	29. 6	54. 7	79. 7	104. 6	129. 7	154. 6	179. 5
5. 5	30. 6	55. 5	80. 7	105. 6	130. 7	155. 6	180. 5
6. 5	31. 6	56. 5	81. 10	106. 6	131. 7	156. 6	181. 5
7. 6	32. 7	57. 5	82. 7	107. 6	132. 7	157. 7	182. 5
8. 7	33. 6	58. 5	83. 5	108. 5	133. 5	158. 6	183. 5
9. 7	34. 5	59. 5	84. 5	109. 5	134. 5	159. 6	184. 5
10. 6	35. 6	60. 5	85. 5	110. 8	135. 5	160. 6	185. 8
11. 6	36. 6	61. 5	86. 7	111. 7	136. 5	161. 8	186. 5
12. 6	37. 5	62. 6	87. 5	112. 5	137. 5	162. 8	187. 5
13. 6	38. 5	63. 6	88. 7	113. 7	138. 5	163. 6	188. 5
14. 5	39. 5	64. 5	89. 5	114. 9	139. 6	164. 5	189. 5
15. 5	40. 5	65. 7	90. 5	115. 7	140. 6	165. 5	190. 10
16. 5	41. 5	66. 5	91. 5	116. 5	141. 5	166. 5	191. 5
17. 5	42. 5	67. 5	92. 7	117. 5	142. 6	167. 5	192. 5
18. 6	43. 5	68. 5	93. 5	118. 6	143. 5	168. 5	193. 6
19. 5	44. 6	69. 5	94. 6	119. 5	144. 5	169. 5	194. 6
20. 5	45. 7	70. 6	95. 5	120. 5	145. 5	170. 5	195. 5
21. 5	46. 8	71. 5	96. 5	121. 6	146. 5	171. 5	196. 5
22. 8	47. 5	72. 5	97. 6	122. 5	147. 5	172. 5	197. 5
23. 6	48. 5	73. 6	98. 5	123. 5	148. 6	173. 5	198. 5
24. 7	49. 5	74. 5	99. 6	124. 5	149. 6	174. 5	199. 5
25. 6	50. 5	75. 6	100. 7	125. 5	150. 7	175. 6	200. 5

Remarks:

Sheet 2.

Subject Miss Kordner Trial 4th

Date Jan. 16, 1931 Time 2:45.

1. 5	26. 6	51. 5	76. 7	101. 7	126. 5	151. 8	176. 5
2. 5	27. 6	52. 6	77. 5	102. 8	127. 6	152. 7	177. 5
3. 5	28. 7	53. 7	78. 5	103. 6	128. 7	153. 6	178. 7
4. 5	29. 6	54. 5	79. 5	104. 6	129. 5	154. 6	179. 8
5. 5	30. 7	55. 5	80. 7	105. 6	130. 6	155. 7	180. 8
6. 5	31. 8	56. 5	81. 6	106. 5	131. 5	156. 8	181. 6
7. 6	32. 6	57. 5	82. 7	107. 7	132. 5	157. 8	182. 5
8. 8	33. 6	58. 7	83. 5	108. 5	133. 6	158. 7	183. 5
9. 5	34. 6	59. 5	84. 6	109. 7	134. 5	159. 6	184. 5
10. 8	35. 6	60. 5	85. 5	110. 5	135. 5	160. 6	185. 5
11. 6	36. 6	61. 5	86. 5	111. 5	136. 6	161. 7	186. 6
12. 5	37. 7	62. 6	87. 8	112. 5	137. 5	162. 5	187. 7
13. 8	38. 5	63. 5	88. 5	113. 5	138. 5	163. 5	188. 5
14. 6	39. 6	64. 5	89. 5	114. 6	139. 7	164. 5	189. 5
15. 6	40. 6	65. 5	90. 5	115. 5	140. 5	165. 5	190. 5
16. 6	41. 6	66. 5	91. 7	116. 5	141. 8	166. 5	191. 5
17. 5	42. 6	67. 5	92. 5	117. 5	142. 6	167. 5	192. 7
18. 6	43. 5	68. 5	93. 6	118. 5	143. 5	168. 6	193. 6
19. 6	44. 5	69. 5	94. 6	119. 5	144. 5	169. 5	194. 5
20. 6	45. 5	70. 5	95. 6	120. 5	145. 7	170. 5	195. 5
21. 5	46. 5	71. 5	96. 5	121. 5	146. 10	171. 5	196. 5
22. 5	47. 5	72. 5	97. 5	122. 5	147. 8	172. 5	197. 6
23. 5	48. 5	73. 6	98. 5	123. 5	148. 8	173. 5	198.
24. 5	49. 8	74. 5	99. 5	124. 5	149. 10	174. 5	199.
25. 7	50. 8	75. 5	100. 8	125. 5	150. 7	175. 6	200.

Remarks:

Pattern Running.

Subject Williams Trial 1st

Date Jan. 5, 1931 Time 10:00

1. 5	26. 5	51. 7	76. 5	101. 10	126. 4	151. 5	176. 6
2. 7	27. 7	52. 10	77. 6	102. 5	127. 4	152. 5	177. 6
3. 6	28. 5	53. 6	78. 6	103. 5	128. 4	153. 5	178. 6
4. 7	29. 5	54. 7	79. 5	104. 5	129. 5	154. 6	179. 6
5. 8	30. 7	55. 8	80. 5	105. 5	130. 4	155. 6	180. 5
6. 8	31. 5	56. 6	81. 5	106. 5	131. 5	156. 5	181. 5
7. 6	32. 7	57. 5	82. 5	107. 5	132. 4	157. 5	182. 4
8. 6	33. 7	58. 6	83. 5	108. 6	133. 5	158. 5	183. 4
9. 8	34. 8	59. 6	84. 6	109. 5	134. 5	159. 5	184. 6
10. 5	35. 6	60. 5	85. 5	110. 5	135. 5	160. 4	185. 4
11. 6	36. 5	61. 5	86. 5	111. 6	136. 4	161. 5	186. 5
12. 5	37. 6	62. 5	87. 6	112. 7	137. 4	162. 4	187. 5
13. 6	38. 8	63. 6	88. 6	113. 6	138. 6	163. 6	188. 5
14. 7	39. 5	64. 5	89. 5	114. 5	139. 4	164. 4	189. 5
15. 7	40. 6	65. 7	90. 5	115. 5	140. 5	165. 4	190. 7
16. 6	41. 6	66. 5	91. 5	116. 4	141. 7	166. 5	191. 5
17. 7	42. 5	67. 5	92. 6	117. 8	142. 4	167. 4	192. 5
18. 6	43. 5	68. 5	93. 6	118. 6	143. 4	168. 7	193. 6
19. 7	44. 6	69. 5	94. 5	119. 4	144. 5	169. 4	194. 4
20. 7	45. 5	70. 7	95. 5	120. 4	145. 5	170. 4	195. 5
21. 5	46. 5	71. 6	96. 6	121. 5	146. 5	171. 7	196. 5
22. 10	47. 6	72. 5	97. 5	122. 4	147. 4	172. 5	197. 5
23. 5	48. 5	73. 5	98. 6	123. 4	148. 5	173. 6	198. 7
24. 5	49. 5	74. 5	99. 6	124. 5	149. 6	174. 5	199. 5
25. 7	50. 5	75. 7	100. 5	125. 5	150. 5	175. 8	200. 5

Remarks: